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FIG. 1.—RUINS OF MISSION OF SAN FRANCISCO DE ESPADA, TEXAS, 1730.

FIG. 2.—RUINED ARCHES OF SAN ANTONIO DE VALERO, SAN ANTONIO, TEXAS.

FIG. 3.—SECOND MISSION OF SAN JOSE, TEXAS

FIG. 4.—RUINS OF THE GRANARY OF THE SECOND MISSION, SAN JOSÉ, TEXAS.

FIG. 5.—PURISIMA CONCEPCION DE ACUÑA. FRONT OF THE MISSION OF SAN ANTONIO, TEXAS, 1731.

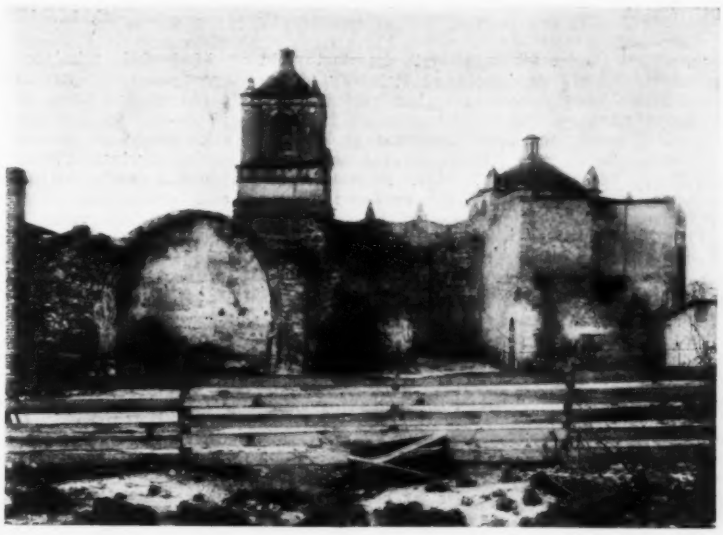


FIG. 6.—REAR OF CONCEPCION MISSION.

CALIFORNIA MISSIONS.

CALIFORNIA MISSIONS.

By CHARLES FREDERICK HOLDER.

IT is generally supposed that it is necessary to go to the Rhine, to England, or to Italy, to see the stepping stones which connect the past with the present, yet in various parts of this country we have ruins and antiquities which reach far into history and with which romance and mystery are richly associated. The famous ruins of Central America, remains of tombs, palaces, pyramids, carry us indefinitely back into the remote history of this country. In the centuries from 1500 we have a period relating to the early conquest of America as rich in romance as that of any land under the sun, and presenting a most graphic field for the future historian or novelist. The present decade has witnessed the undoing of Spain, and her colonial possessions, which were seized and held only with the greatest heroism, have been taken, and the proudest of nations, the race which once led in science, discovery, and colonization, has been humiliated by a stronger and dominant race.

The early history of Spain in America is of intense interest, and it cannot be perused even casually without arousing admiration of the men who surmounted every difficulty and who were the real conquerors of the New World. What more unpromising region than Texas in 1532 could be imagined? Filled with hostile Indians, its possibilities absolutely unknown, its coast forbidding, few would have essayed it; but this vast region, with its extremes from torrid deserts to cold forests, was crossed and recrossed by many adventurers—Spanish and French—who left as their only monuments some of the most interesting ruins in America. Probably the first Europeans to land on Texas shores were the members of the expedition under Alonso Alvarez Pineda in 1519. Pánfilo de Narvaez was appointed governor of this unknown country in 1528, and with a party began its exploration, resulting in the death of all except four. In this year Alvar Nuñez, with Castillo, Dorantez, and Estevanico, made their way from some point on the Texan coast, between Galveston and the mouth of the Rio Colorado, to Sonora, reaching, in all probability, the head waters of the Yaqui. Other parties visited Texas in 1540 and 1543, one under Francisco Vazquez de Coronado, and another under Hernando de Soto.

One of the first Spanish governors of Texas, as early as 1692, was Domingo Teran de los Rios, and one of the first Friars to enter Texas, Antonio Olivares, who, after a march as far as the river Frio, reported to Bishop Galmido and was sent to Mexico for aid, hoping to extend the chain of missions across the Rio Grande. Texas at this time was entirely unknown; it had no name, and was a part of Florida in a general sense; and that bravery and tenacity of purpose were required to penetrate such a country can readily be realized. The expedition of La Salle is famous in history. It was to settle the country and convert the natives, but owing to internal dissensions it was a failure, and nearly the entire party lost their lives. The French and Spanish sent out many expeditions in rapid succession, and as a result, a number of forts and missions were established, the latter in some instances remaining to-day as interesting ruins.

One of the interesting missions of the seventeenth century was established through the influence of Viceroy Galve, who sent Leon on an expedition into Texas with the view to the establishment of missions. The Fathers were from the college of Santa Cruz of Querétaro, and were Franciscans. In 1690 they established a wooden mission near the Trinity River, and called it San Francisco de los Tejas. Padre Foncubierta was made president, and with a few men, horses, and some provisions, he began the work of converting the Tejas natives, whose name was adopted as the name for the modern State. Orders were now given Governor Teran de los Rios to make a study of the entire region, pacify the natives, and establish eight missions, for which purpose nine Franciscans were brought from Mexico. Another mission, Jesus Maria y José, was built, but the work of proselyting did not progress, because some of the priests had died. Drought, heat, sudden changes in the weather, the hostility of the Indians, all combined to discourage the work, and finally, in 1693, the government, disgusted at the long series of disasters, ordered that the missions be deserted and the priests, after burying the bells, left them and retreated to Coahuila, thus ending another attempt of the Spanish to occupy Texas.

Most of the missions were of the type shown in the accompanying illustrations, and made of stone, wood, or adobe, and some of pretentious architecture, provided with bells shipped from Spain to Mexico. For some reason the many missions of Coahuila, the neighboring province in Mexico, were much more successful, probably due to the fact that here were more *presidios* and more soldiers to keep the Indian converts under rule. In 1786 there were eighteen hundred mission Indians, about two-thirds of whom were Tlascaltecs. The Querétaro Franciscans gave up their missions to the Jalisco Friars in 1771-2, and at this time they had baptized in Coahuila and Texas about ten thousand natives. The rise, fall, and ruin of the missions in these centuries is like the swell of the troubled ocean; the Spanish and French struggling for supremacy, the men for gain, the officers for glory, the adventurers for fame and loot, and the Friars bent upon saving the souls of the unlettered savages, who too often took their scalps for their pains. These remarkable invasions, which have left us our only ruins in America, the remains of the old stone missions which were planted and literally built with the blood of these indefatigable men, are well illustrated by the one led by Louis de St. Denis in 1713, who was sent by the governor of Louisiana on a visit to the missions west of the Red River. St. Louis left the vicinity of Mobile with twenty-four Canadians, and went to the country of Tejas, and obtaining a force of them under Chief Bernardino, continued on into the Spanish country. He fought the Apaches on the Rio San Marcos, but reached the Rio Grande and the *presidio* of San Juan Bautista in safety, where he became the guest of the Spanish commandant Diego Ramon. St. Louis here fell in love and married the niece of Ramon, and appears to have joined cause with the Spaniards. As a result of his enthusiasm an expedition for the exploration of Texas and the establishment of missions was formulated under the head of Domingo Ramon, St. Louis being now an officer of high rank under salary of the Spanish government.

This mission-establishing expedition was typical of these movements and numbered about seventy-five persons. Twenty-five were cavalrymen, and there were eight women and two children, as towns were to be established. The most important part of the *entourage* was the priests or Friars who were to convert the savage natives, and plant the cross in the unknown land. The Friars were architects, teachers, and mechanics. It was their business to assume the practical part of the work. While converting the natives they employed them to build the missions in many instances, nearly all the old buildings being the result of the labor of native artisans under the instructions of the Friars. The ecclesiastics of this party were six Franciscans from Querétaro and four Friars from Zacatecas. With the expedition were twenty-five or thirty horses, over a thousand goats, pack animals, and oxen, so that while the number of fighting men was few, they made a pretentious showing as they marched on, heading for the interior of what is now Texas. They had some difficulty in crossing the streams, losing at the San Marcos eighty-three horses in a deep pool. They crossed the Colorado, and in June, 1716, reached the river Trinity, and finding many Tejas who received them kindly, they decided to make a stand. A treaty was consummated with the Indians and a settlement made in a land described eloquently by Ramon as one of fruit and flowers, charming to the eye and senses. The streams abounded in fish; buffalo and deer grazed on the prairies, and in the forest the wild turkey was found—all suggestive of a land of plenty.

The Indians were particularly tractable, and even welcomed the Friars, and it was decided to establish the first mission at the town of Nacodoches; here was built the mission of San Francisco. About sixty miles from here there was a large settlement of Asinais, and in their midst was established the mission of Purísima Concepcion. A third mission was established sixty miles southeast of the latter, and called Guadalupe. In the erection of all these the Friars used designs, the same copied from other buildings in Mexico. The whites laid out the work, large numbers of natives being employed as laborers and unskilled mechanics. Nearly all the missions were made more or less attractive in appearance; some imposing, and all were constructed to last, being veritable fortresses, possibly with a view to contingencies which might arise with hostile natives. This ponderous method of architecture has resulted in the preservation of many

THE INTERIOR OF SAN XAVIER MISSION, ARIZONA.

CALIFORNIA MISSIONS.

of these old ruins until to-day—virtually the stepping stones between the past and present history of Texas, a period that in romance is hardly equaled and certainly not generally appreciated.

Ramon and St. Denis were eminently successful and the work of founding missions and converting the Indians went rapidly on. In July, 1716, a fourth mission was established at San José, about fifty miles west of Guadalupe, among the Nazones, peaceful Indians who had many *rancherías* in the vicinity. The missions were established in the most active Indian centers, or within reach of the greatest numbers, and by the end of the year the region between the Trinity and Red rivers, said to be the garden spot of Texas, was sprinkled with settlements, each having its mission and its log cabins. Ramon established the *presidio* of Nuestra Señora de los Dolores de los Tejas a few miles south of the mission of San Francisco, and not many weeks later two other missions were founded—Dolores and San Miguel de Cuellar, the mission buildings being erected in the heart of the Aes and Adaes country.

For many months the Friars worked and labored, but as with their predecessors, they found it almost impossible to civilize the natives and make them live according to the rules which governed the Spanish or French Then came internal dissensions. St. Louis was arrested by Spanish officials, sent to Guatemala, but finally returned, and we find him again on the French side and commandant at the French fort at Natchitoches. The Spanish, still undismayed by the ill success of their Friars, continued their establishment of missions. In 1716 Martin de Alarcon was made governor of Coahuila and Texas, and in 1718 he built a large mission on the river St. Anthony, San Antonio of to-day, and established the *presidio* of San Antonio de Béjar. The mission was called San Antonio de Velero, and Padre Antonio Alivares was given charge, removing his neophytes from the abandoned mission of San Francisco. Like his predecessors, Alarcon soon made enemies. He visited all the old missions and those of St. Louis, placing small forces at each to keep the natives in subjection; but his work did not satisfy the Friars, and he soon resigned. Then war between France and Spain was declared, and the French of Louisiana marched on Texas. In 1719 the French, with a force of native allies, captured the mission of San Miguel, and the natives, taking advantage of the trouble, destroyed many of the missions, whose ruins can still be located—crumbling monuments of the times. The missions of San Antonio now became the center of interest, and virtually the Spanish capital, and in 1720 the Friars established a new mission at Béjar, calling it San José y San Miguel de Aguayo, the building illustrating the indomitable spirit which characterized these men.

Following another French invasion, an expedition under the Marquis de Aguayo re-equipped the deserted missions, five of which were destroyed, or partly so, all being rehabilitated. At this time all the missions except Concepcion had been destroyed. The old mission of San Miguel was also rebuilt by Aguayo, and a new era of prosperity began, only to be cut short by disaster to his people. Sudden cold weather killed 4,500 horses and 700 mules, but this determined officer was never discouraged. The life was strenuous beyond expression, yet he appears to have been equal to all demands upon him. He now built a strong adobe fort at San Antonio and founded a fine mission—San Francisco Javier de Nájera. It was this officer who fortified the bay of Espíritu Santo, erecting a new *presidio* there, and a new mission was founded with much ceremony, and called Espíritu Santo de Zúñiga, later removed to San Antonio. It was at this mission that Capt. Ramon was killed by the Indians, who abandoned it on the ground of ill-treatment, but the fathers established others fifty miles inland. It was about this time that Spain introduced many settlers from the Canary Islands into Texas at San Antonio, and the king gave $12,000 toward erecting a mission church.

We show six views in illustration of the San Antonio missions, now famous as the only ruins in Texas, which give an excellent idea of the architecture of the time. Fig. 2 shows the first mission of San Antonio, Concepcion, with its double belfry, a massive pile of stone and mortar. The solid nature of its construction is seen in the rear view, Fig. 1, where the ravages of time have begun to gnaw away the edges. The second mission, Fig. 3, was perhaps the most artistic of all. The front was ornate, and originally bore much ornamentation. The arches of this venerable pile, Fig. 4, appear more like the sections of some great reservoir, or some of the buildings still seen about Rome, and were of the most ponderous nature. Even the granary of the second mission, Fig. 5, is a massive structure resembling a fort more than a mere storehouse, and, doubtless, it was intended as a fortress where the Friars could make a stand if necessary against the Indians. The third mission of San Antonio, Fig. 6, is of a simple type—a long building, with three bells, built in a most primitive fashion. Singularly enough, the fourth mission, Fig. 5, is the least attractive, and presents the most appearance of a ruin. There were five missions on the San Antonio River within fifteen miles. Morfi refers to Purísima Concepcion as being "very beautiful," and San José, he states, "was the finest building in New Spain at this time." The latter was a fortified temple and had a large plaza 600 feet square, surrounded by tall walls, each face having a gateway over which was a bastion, while the walls were pierced with loopholes for the musketeers. Morfi describes this building as having three vaulted aisles topped with a fine cupola. The ornamentation was rich and beautiful; the house of the Friars commodious, and contained a fine polished stairway of stone, at the head of which was an image of St. Joseph. In the mission was a well-equipped armory, provided with weapons necessary to repel any invasion. The mission of San Juan Capistrano resembles Concepcion. Espíritu Santo was also a combination of fortress and mission, and was, with the home of the padres, community buildings, etc., surrounded by a high wall.

These quaint ruins are all that is left to tell the story of successive French and Spanish conquests of this region. They tell of the rise and fall of the Spaniards, but also suggest the failure to sustain the series of supreme efforts to conquer and civilize the natives of this vast region of which the Apaches were the most dreaded. In 1729 or 1730, the latter, to the number of 500, appeared at San Antonio and challenged the Spaniards to battle, but were ultimately defeated; yet they continued their depredations, and made life very uncertain. So aggressive were the natives in 1731 that the Friars moved the three missions —Francisco, Concepcion, and San José—near to the *presidio* of Béjar, and at this time San José was changed to San Juan Capistrano. Many changes were made in the years to come, the Friars always losing influence, and in 1743 the Comanches destroyed the mission of San Sebastian Sabá and massacred the Friars, in retaliation of which the friends of the Friars gathered an army and marched against the Comanches, but they were put to flight. From now on the Spaniards and the missions became the objective of all marauding Indians, and in 1767 the viceroy ordered the abandonment of the missions. Up to this time the crown had expended over six millions of dollars in Texas, and in 1782 the vast domain, owing to the continued attacks of savages, could boast of but 2,600 whites, mostly about the five missions in the vicinity of San Antonio. This large sum, hundreds of lives, and the strenuous labors of scores of brilliant men through several centuries, is represented to-day by these crumbling ruins in Texas. What they accomplished it would be difficult to state, but that they paved the way to a later civilization must be accepted. According to B. Morfi, San Antonio Béjar was a ruin in 1785. It cost $80,000. At San Antonio 1,972 natives were baptized down to 1762. At this time the mission owned 1,200 cattle, 300 horses, 1,200 sheep, but in 1793 its population, its converts and their descendants had dwindled to a pitiful 43. At Purísima, about six miles from the present San Antonio, 792 natives were baptized, and in 1762 it owned 300 horses, 2,200 sheep; yet in 1793 its population amounted to but 51 souls. San José baptized 1,054; San Juan, 847; population in 1793, 34. San Francisco mission baptized 815; population in 1782, 80; and so on the dreary story of degeneracy might be told through all these missions, once rich with large flocks. They had become, so far as their importance was concerned, virtual ruins in the eighteenth century, and to-day no more graphic or romantic story is told in America than that of the quaint ruins about San Antonio Béjar.

THE MISSION OF SAN XAVIER, ARIZONA.

CALIFORNIA MISSIONS.

"PREDIGESTED" AND "MALTED" BREAKFAST FOODS.

THE idea of having part of the process of digestion performed outside of the body is not a new one, nor is it confined to human food. About thirty years ago there was a furor over malted fodder for cattle, which it was claimed would greatly increase the strength and flesh of the animals by sparing them part of the work of digestion. It was soon found, however, that the cattle did fully as well when left to perform their own work of digestion in the way that nature intended.

Physicians have used predigested foods of different sorts for their patients for many years. Since the diastase of malt imitates the work of the diastase of saliva and pancreas so well, it is the common means of predigesting carbohydrates, when that is necessary, just as the preparations of pepsin and pancreatic juice are used for the predigestion of protein. Ordinarily predigested foods are intended for invalids under special conditions, and for them only on the doctor's orders. The modern American breakfast foods, however, which claim to be predigested are recommended by the manufacturers for general use.

The diastase of malt is, as has been said, supposed to change the insoluble starch in these cereal foods into more soluble forms. If sufficient malt were used under the right conditions, a considerable portion of the starch would undoubtedly be thus transformed. But this does not appear to be the case in the majority of the preparations which claim to be predigested. Among a number of malted breakfast cereals analyzed at the Iowa Experiment Station* the largest amount of soluble carbohydrates found was 13.23 per cent of the total carbohydrates, the next largest 10.91 per cent, and the lowest 0.35 per cent, while the average was in the neighborhood of 5 per cent. Judging from other analyses,† dextrin forms the largest part of the soluble carbohydrates in these preparations. In some cases the soluble carbohydrates may have been formed by the action of malt, but there is reason to believe that in certain cases soluble carbohydrates like glucose were simply added during the process of manufacture. Moreover, most of these malted goods seem to have been parched or cooked in part by dry heat, and some dextrin or other soluble carbohydrate is commonly produced from starch by dry heat without the aid of diastase. Hence it appears that in most of the malted cereals very little of the starch is converted into any soluble form other than dextrin, and that the dry heat of cooking produced at least a part of that change. Certainly the claims made for some brands that the carbohydrates are completely or largely predigested are quite unwarranted. Furthermore, it must be remembered that if the cereal foods are thoroughly cooked at home before serving, the proportion of soluble or at least gelatinized carbohydrates formed will be fairly high, certainly as high or higher than in the predigested foods designed to be eaten raw. Malt has a characteristic taste which is relished by many, and on this account the malted cereals are often liked. Their use helps to add variety to the diet, which, as noted above, is an advantage.

It is interesting to note that a product in appearance and taste very closely resembling some of the granular specially prepared breakfast foods may be made at home by dipping small pieces of Graham bread in a dilute mixture of glucose and malt, drying in an oven, and crushing.

It seems to be the case, then, that these special cereal foods do not merit the name "predigested," and this may be an advantage rather than the reverse. It is questionable whether it would be of advantage to a healthy person to have his food artificially digested. The body under normal conditions is well adapted to utilize such foods as the ordinary mixed diet provides, among them the carbohydrates from the cereals. Moreover, it is generally believed that for the digestive organs, as for all others of the body, the amount of exercise they are normally fitted to perform is an advantage rather than the reverse. It has been said that "a man has no more need of predigested food than a sound man has of crutches." If the digestive organs are out of order it may be well to save them work, but troubles of digestion are often very complicated affairs and the average person rarely has the knowledge needed to prescribe for himself. In general, those who are well should do their own work of

* Iowa Sta. Bul. 74, p. 133.
† Mich. Sta. Bul. 211, p. 19.

digestion and those who are ill should consult a competent physician.

While breakfast foods of this class are usually not predigested, as they claim to be, they are, on the other hand, quite free from harmful ingredients and have much the same nutritive value as other preparations of similar grains and have a flavor which many like. They are on an average higher priced than the others, but aside from this consideration of economy there is no reason why those who like them should not use them as they do other ready-to-eat cereals.—From Farmer's Bulletin 249, issued by the U. S. Department of Agriculture.

THE MOND PRODUCER.

By DR. J. D. PENNOCK.

THE Solvay Process Company, at its plant at Detroit, installed the first Mond producer plant in the United States in 1898, and I believe this is the only one being operated at the present time. The plant consists of six Mond and two modified Mond producers, which convert to gas about 110 tons of coal per day. I would say that the plant has worked satisfactorily, and with only a reasonable amount of repairs. The acid tower, however, had soon to be rebuilt because of unsuitable tiling with which it was first lined.

Not all coals are suitable for the Mond producer. First, a bituminous coal low in percentage of bitumen, and inferior in coking qualities, must be used to avoid clinkering; second, as it is necessary to obtain a high yield of ammonia to offset the extra cost of installation, depreciation, and operation of the by-product portion of the producer plant, a coal high in percentage of nitrogen must be employed. After a careful ultimate analysis of the slack used in the Mond producer in England, we were fortunate in finding one corresponding closely to it in the Hocking Valley coal fields. It is a coal approaching a lignite in composition, having 6 to 7 per cent of water of constitution, and a high percentage of oxygen, and is especially desirable because of a high percentage of nitrogen. The analyses of the English coal and the Hocking Valley are as follows:

	Hocking Valley Nut Coal.	English Producer Coal.
	Per cent.	Per cent.
Moisture (chemically combined)	7·84	0·85
Volatile matter	27·95	32·14
Fixed carbon	50·75	48·93
Ash	13·46	11·10
Sulphur	1·50	1·68
Nitrogen	1·45	1·35

The relation of the hydrogen to the oxygen in the coal, which is an important factor in the clinkering and the yield of ammonia and tar, is as follows:

	Hydrogen.	Oxygen.	Available Hydrogen.
	Per cent.	Per cent.	Per cent.
English coal	3·90	12·08	2·32
Hocking Valley	4·65	10·86	3·26

The Mond gas at Detroit is somewhat different from that obtained in England, as the following comparison shows:

	Mond Gas.	
	Detroit.	England.
	Per cent.	Per cent.
Carbon dioxide	14·6	16·5
Oxygen	0·5	—
Carbon monoxide	10·3	11·0
Methane	5·3	2·0
Hydrogen	23·5	27·5
Nitrogen	55·8	43·0
Total combustible	39·1	40·5
Gross B.T.U. per cb. ft.	163·5	145·5
Net B.T.U. per cb. ft.	146·6	129·7

The yield of ammonia amounts to 70 to 75 pounds of sulphate per long ton of coal. Tar amounting to 55 to 65 pounds per ton of coal is also recovered; this is much lighter in gravity than the ordinary coal tar and has little value except as a fuel and as such is worth about 1s. per gallon.

Taylor Producer.

I might say a few words in addition to what has already been stated about ordinary producer gas.

For the production of gas to be used under drying furnaces we have at the works of the Solvay Process Company, at Syracuse, thirty Taylor producers, which gasify 134 tons of anthracite buckwheat coal per day. The air is introduced by means of live steam injector, and the coal for the steam used is about 10 per cent of that gasified. These producers are not supplied with automatic and continuous feed. The analysis of gas advertised as attainable by the promoter of the Taylor producer is seldom obtained in practice. The temperature of the producer chamber above the fuel bed is so high, due to unevenly covered surface of the bed and the holes through the bed, that the water is dissociated, hydrogen formed and the percentage of carbonic acid gas increased.

Temperatures taken with electrical pyrometers at various points in the producer were as follows:

	Number of Producer.			
	1	3	5	7
	°C.	°C.	°C.	°C.
Temp. at top of fuel	950	955	965	970
2 ins. above surface	900	910	910	905
1 ft. above surface	650	650	660	650
2 ft. above surface at outlet.	600	600	605	595

The analyses of producer gas, as made at Syracuse and that advertised by Mr. Taylor, are:

	Syracuse.	Mr. Taylor.
	Per cent.	Per cent.
Carbon dioxide	9·4	4·5
Oxygen	0·2	0·6
Carbon monoxide	22·7	25·5
Methane	1·0	1·0
Hydrogen	16·2	12·0
Nitrogen	51·5	56·4
B.T.U. per cb. ft.—Gross	136·4	131·7
B.T.U. per cb. ft.—Net	127·5	124·8

Theoretical Considerations.

I wish to call attention to a few theoretical considerations which have a bearing upon the efficiency of the various gases in the gas engine. The table at foot of page gives the analyses of gases, their heat value, the theoretical amount of air required for combustion and the corresponding pressure, and the relative volume of gases before and after combustion under the same conditions of temperature. The sample of coke oven gas represents that which is available during the first eight hours of the coking process.

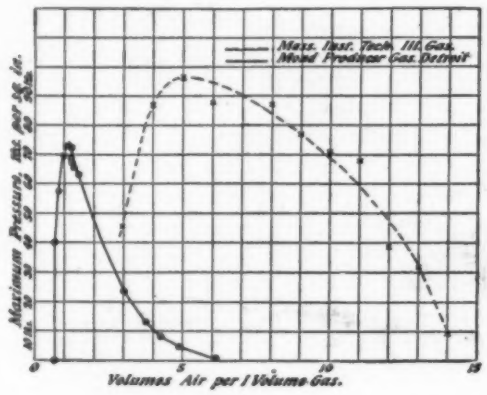


FIG. 1.

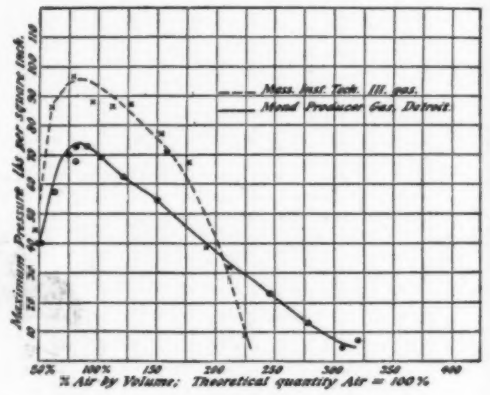

Mass. Inst. Tech. Ill. gas.
Mond Producer Gas. Detroit.
Maximum Pressure (lbs per square inch.
% Air by Volume; Theoretical quantity Air = 100%

FIG. 2.

Composition: Per Cent by Volume.

In the theoretical calculations in this paper the following values have been used:

	Calories per M³ (0°C. and 760 mm.		B.T.U. per cb. ft. (60° F. and 30 ins.)	
	Gross.	Net.	Gross.	Net.
Hydrogen	3061	2600	324·2	277·1
Carbon monoxide	3036	3036	323·5	323·5
Methane	9478	8531	1010·0	909·1
Ethane	16558	15151	1764·6	1614·6
Ethylene	14900	13957	1588·0	1487·4
Acetylene	13857	13391	1476·7	1427·1
Benzene	35725	34298	3807·2	3655·1
Illuminants {1/4 C_6H_6} {3/4 C_2H_4}	20090	19042	2141·6	2029·3

	Composition: Per Cent. by Volume.					
	Taylor Producer.	Mond Producer.	Coke Oven.	Blast Furnace.	Natural Gas (Pittsburg).	Natural Gas (Ohio).
Carbon dioxide	8·4	14·6	1·8	11·7	0·6	0·2
Benzene	—	—	1·0	—	3·6 (ethane)	—
Ethylene	—	—	4·8	—	0·7	0·2
Oxygen	0·2	0·5	0·2	—	1·1	0·4
Carbon monoxide	22·7	10·3	4·2	27·5	1·0	0·6
Methane	1·0	5·3	36·7	—	72·2	92·8
Hydrogen	16·2	23·5	45·5	—	20·0	1·9
Nitrogen	51·5	45·8	5·8	60·8	—	3·6
Calories per M³ (0°C and 760 mm.) —Gross	1280	1533	6071	835	8185	8001
Calories per M³ (0°C and 760 mm.) —Net	1196	1376	5454	835	7352	8012
B.T.U. per cb. ft. (60° F. and 30″) —Gross	136·4	163·4	647·2	89·0	872·0	948·0
B.T.U. per cb. ft. (60° F. and 30″) —Net	127·5	146·6	581·2	89·0	783·7	854·0
Combustion with the theoretical quantity of air—						
Vol. air per 1 vol. gas	1·00	1·27	5·64	0·65	7·92	8·79
Theoretical temperature °C.	2678	2634	3459	2227	3380	3331
Theoretical pressure atm.	8·9	8·9	12·2	7·5	12·2	12·2
Theoretical pressure, lbs. per sq. in.	131	131	179	110	179	179
Vol. decreased by combustion (original vol. = 100 per cent.)	9·8	7·5	3·7	8·4	0·9	0·1

Sp. Hts. at const. vol. used in calculation: Water, 0·37; carbon dioxide, 0·17; nitrogen, 0·17.

By gross is meant that the temperature is brought to the same point before and after combustion (figured for 18 deg. C.) and that the water formed is condensed.

By net is meant that the temperature is brought to the same point before and after combustion (figured for 100 deg. C.) and that the water is not condensed.

Calculations based on Thompson's results "Thermochemische Untersuchungen."

The practical value of efficiency of a fuel gas within the cylinder of a gas engine is ordinarily considered to be in direct proportion to the heat units of that gas, but this is not strictly true; fuel gases of the various kinds have different percentages of a number of different gases, each having its own individual qualities which in the explosion effect the transference of thermal energy into mechanical.

For instance, there is a difference in the inflammation temperature of the various constituents of the gases; hydrogen ignites at 550 deg. C., carbon monoxide at 655 deg. C., methane at 656 deg. C. It is said that a gas containing a high percentage of hydrogen is particularly liable to pre-ignition. While we know the temperature of ignition of the gases singly, nothing is known concerning the ignition temperature of a mixture of these gases in various proportions at atmospheric and other pressures. Experiments in this direction would doubtless be of great assistance to designers of gas engines.

Then there is the question of propagation of flame and its relation to the economical production of power in the gas engine. The normal propagation of flames (according to Berthelot) of hydrogen is 4.3 meters per second, methane 0.62 meter, and carbon monoxide 2 meters per second.

The experiments made at the Institute of Technology in Boston give the rapidity of explosion of hydrogen with the theoretical quantity of air as more than ten times that of illuminating gas. Berthelot says when two combustible gases, such as hydrogen and carbon monoxide, are burned in oxygen, the rate is by no means the mean of that of the two gases. They appear to burn separately each with its own rapidity. Further, water, one of the products of explosion, dissociates at 874 to 900 deg. C., and may this not take place at the expense of thermal energy and may it not happen that there should be sufficient cooling of the cylinder to prevent recombination and giving up of that heat before the exhaust opens? The dissociation of carbon dioxide begins at 1,300 deg. C., but, of course, this is never reached. All of these considerations doubtless have some bearing on the efficiency of the gas for power development.

Mean Pressure Efficiency and Calorific Values.

From the Technology measurements of the mean pressures obtained during the first 0.2 second after explosion, using all proportions of air to gas, it appears that, in the case of water gas, the best efficiency results when using that quantity of air which gives a theoretical maximum pressure of about 8.4 atmospheres (124 pounds per square inch). Using this quantity of air with the above gases (except the blast furnace gas) the results shown at top of next page are obtained.

By the above charts, one of some explosion experiments made with the Mond gas at Detroit under direction of Mr. A. F. Shattuck, and the other of some explosions of illuminating gas of 721 B.T.U. (gross) mixed with various percentages of air, made by a student at the Institute of Technology in Boston, it will be observed that the maximum pressure obtained is about one-half the theoretical; further, that this maximum pressure is obtained when 80 to 85 per cent of the theoretical air necessary for combustion is used.

Coke Oven Gas.

We now come to the consideration of retort coke oven gas for gas engines. While it is true that a coke oven gas is similar in analysis to coal gas, or illuminating gas made in the well-known gas retort, the composition of the coke oven gas is within the control of the operator; the ovens may be so regulated that the hydrogen may be low or high in percentage; that the carbon dioxide may be reduced to a minimum or almost eliminated, or it may be of such a percentage as to materially deteriorate the gas for illuminating or power. This is made possible because of the large size of the charge of coal in the by-product oven; the possibility of regulating the temperature of coking and the time of coking. In coal gas manufacture, a small re-

	Syracuse Producer.	Detroit Producer.	Coke Oven.	Blast Furnace.	Natural Pitts.	Natural Ohio.
Vol. of air per 1 vol. gas	1·09	1·50	8·93	0·85	12·4	12·5
Theoretical temperature, °C.	2560	2435	2358	2227	2313	2302
Theoretical pressure (max.) atm.	8·4	8·4	8·4	7·5	8·4	8·4
Theoretical pressure, lb. per sq. in.	124	124	124	110	124	124
Ratio of mean pressure efficiency equal vol. of gas	1	1·20	4·76	0·70	6·41	6·96
Ratio of calorific values of equal vol. of gas	1	1·18	4·56	0·70	6·15	6·70

tort of 300 or 400 pounds capacity, fired with coke and coked in five or six hours, is used. In the by-product oven, eight or nine tons of coal are coked in a space approximately 30 feet long, 8 feet high, and 17 inches wide, during a period of twenty-two to twenty-four hours; by manipulating properly the valves between the oven and the hydraulic main, turning the gas first into one and then into the other main, the quality of the gas may be regulated to a nicety; by the proper regulation of the supply of the gas to the oven for the coking process and by the regulation of the temperature of the flues by electrical pyrometers and Seger cones, the temperature of the distillation within the oven may be maintained at any desired degree. We may thus obtain by proper manipulation gas of varied composition, as is shown by the following analyses:

Analyses of Gas.

	Gas first 8 hours.	Gas for 16 hrs. after.	Average Gas for 24 hours.	Enriched Gas as delivered.
	Per cent.	Per cent.	Per cent.	Per cent.
Carbon dioxide	1·7	1·9	1·8	1·9
Benzene	0·5	0·2	0·3	0·9
Ethylene	4·7	1·5	2·9	4·8
Oxygen	0·4	0·5	0·5	0·5
Carbon monoxide	4·8	4·5	4·6	4·8
Methane	42·0	32·0	36·5	42·0
Hydrogen	35·0	51·0	43·8	35·0
Nitrogen	10·9	8·4	9·5	10·4
B.T.U. per cb.ft.				
Gross	683	565	618	701
Net	614	502	551	631
Calories per M³				
Gross	6078	5027	5500	6235
Net	5466	4471	4901	5619

Nine hundred thousand cubic feet per day of enriched gas of 18 candle-power were delivered during the year 1904 from the Semet-Solvay Company plant of forty ovens at Chester, Pa., to the Chester Gas Company, which, in turn, dealt it out to consumers for illuminating, gas engines, and fuel purposes.

Gas of the quality shown in the table of analyses, containing a high percentage of benzine and methane, and low percentage of hydrogen, is formed during the early stages of the coking process. The gas formed in the latter part is practically devoid of benzine and ethylene, the illuminants, and high in percentage of hydrogen. As it is desirable for power purposes to have a gas of minimum hydrogen to avoid possibility of pre-ignition, gas of the quality represented by the first analysis is the best.

The following chart shows how the British thermal units fall off in the tenth hour, and likewise how the per cent of methane diminishes and the hydrogen increases.

The distillation process proceeds from the top downward, and the heat reaches the center of the mass of coal very slowly.

Experiments were made and temperatures taken by the electrical pyrometer every fifteen minutes from several locations in the oven, and also above the mass of coal; here the lowest temperature was about 720 deg. C. The temperature of the heating flues, three in number, horizontally placed, was 1,050 to 1,150 deg. C.

Quality of Gas Dependent on Composition of Coal and Heat of Oven.

The quality of the gas is not only dependent upon the heat of the oven, but also very largely upon the quality of the coal. This is well known and recognized when considering the Pennsylvania bituminous coking and gas coals and their relation to heavy hydrocarbons or illuminants in the gas, but that different coals when coked in tight ovens, which exclude the air, give varying percentages of carbon dioxide, is not well known. Some coals of the Illinois and Indiana region and the Far West, more or less of a lignitic nature, give a gas containing as much as 7 or 8 per cent of carbon dioxide gas, whereas a Pennsylvania coal under the same oven conditions would give only 1.5 to 2 per cent. This naturally would cut down the B.T.U. considerably, and reduce largely the efficiency in a gas engine. The reason for this high per cent of CO_2 in the gas is the high percentage of oxygen in the coal. An analysis of an Illinois coal, Big Muddy, for instance, shows 12 per cent oxygen. In it there is a large excess of oxygen over that required to combine with hydrogen in the coal, and this excess combines with carbon to form an abnormally high percentage of carbon monoxide and dioxide.

Coke Oven Gas at Detroit and Milwaukee.

It will be observed from the following table that the gas at Detroit and Milwaukee is considerably richer in heat units than that previously described as being made at Chester. The increase in energy for gas engines per unit of gas is due to the greater amount of benzine, toluene, and xylene it contains. The process by which this is accomplished may be described as follows:

As before stated, the gas evolved during the early part of the coking period is richest in heat-giving constituents; and hence this rich gas, that evolved during the first seven or eight hours, is separated from that made during the remaining sixteen hours, and afterward further enriched by means of the benzine and its homologues taken from the lean gas.

The Semet-Solvay coke ovens, 120 at Detroit and 80

Analysis of Gas for February, 1905.

	Milwaukee.	Detroit.
	Per cent.	Per cent.
Carbon dioxide	1·4	1·3
Benzene	1·3	1·2
Ethylene	4·3	4·2
Oxygen	0·4	0·5
Carbon monoxide	4·0	5·1
Methane	36·8	35·5
Hydrogen	47·0	48·0
Nitrogen	4·8	4·2
B.T.U. per cb. ft.—Gross	602	679
B.T.U. per cb. ft.—Net	621	610
Calories per M³.—Gross	6154	6044
Calories per M³—Net	5528	5430

at Milwaukee, during the year 1904 have delivered to the gas companies of these cities gas of about 675 B.T.U. (gross) and of 19 to 21 candle-power, at the rate of 2,700,000 cubic feet and 1,900,000 cubic feet per day.

Daily Production During First Half of March, 1905.

	Coal Coked.	Gas Delivered.	Gas per Ton Coal.
	Tons.	M.	Cub. Ft.
Milwaukee	588	1,999	3400
Detroit	888	2.752	3100

M=1000 cb. ft.

Objection to Coke Oven Gas on Account of Sulphur.

Objection to the use of coke oven gas, without previous treatment to remove the sulphur, cannot be invariably maintained. Our own experience at Syracuse for several years with a 125-horse-power Westinghouse engine developing 85 B.H.P.—90 pounds pressure—on coke oven gas of 450 B.T.U. (net) (28 cubic feet gas per B.H.P.), made from a coal containing 1.1 per cent, is that no serious corrosion has taken place due to sulphureted hydrogen or sulphuric acid.

If, however, water were mixed with the lubricating oil in the crank case, enough sulphuric acid would be soon absorbed to cause attack on the metal.

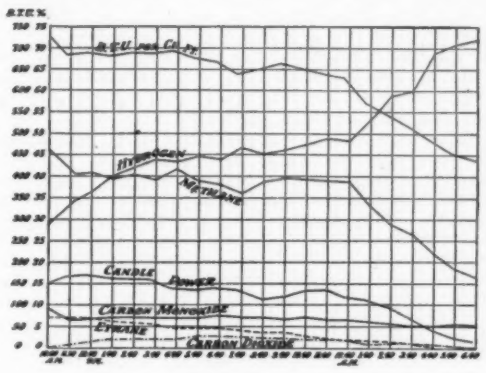


FIG. 3.

Of twenty-two gas-engine installations in Germany, of a total of 13,000 horse-power, working on coke oven gas, eleven, or 50 per cent, do not find it necessary to purify the gas. The others use bog-ore or saw dust. With efficient tar extractors and ammonia washers, tar and dust are readily removed. One of these German installations was using a gas with 0.2 per cent sulphur without injurious effect on the iron.

Pre-ignition.

Pre-ignition or explosion before the completion of the compression is said to more often happen with coke oven than with other fuel gases, like producer and natural gas, and the reason given for it is the high percentage of hydrogen. Authorities vary as to the cause of pre-ignition. If pre-ignition is chargeable to high percentage of hydrogen, coke oven gas is no more liable to pre-ignition than Mond producer, or ordinary producer gas; unquestionably we must consider the percentage of hydrogen in the explosive mixture. By the following it will be seen that the coke oven gas, used in the above table of gases, when mixed with that amount of air which gives the maximum efficiency in the engine, contains less hydrogen than the proper mixture of producer gas and air.

Pre-ignition is not common with small engines up to 50 horse-power, and with large engines is no more frequent with coke oven gas than with other fuels. Of eight managers of plants using coke oven gas in engines up to 750 horse-power, whose opinion was asked concerning pre-ignition, two stated that they had had some pre-ignition, and six had never been troubled with it, though the hydrogen ran as high as 50 per cent in some instances. One of the managers who had trouble said that he had overcome it by varying the compression in inverse proportion to the value of the gas mixture.

One of the greatest authorities in England, who has installed many engines of various types and worked them with gases of different kinds, in writing to our company said that he had used coke oven gas in a 40-horse-power, 107 pounds compression, and 140-horse-power, 95 pounds compression engine without being troubled with pre-ignition, that he had worked a Vogt engine to a pressure of 200 pounds on coal gas, practically the same as coke oven gas without trouble, and many others from 100 to 650 horse-power. He further says, "that probably when a gas contains more than 30 per cent of hydrogen the additional hydrogen has but little effect upon the question of pre-ignition." He further states, "in probability the effect of free hydrogen in producing pre-ignition is not the question of temperature at which free hydrogen combines with the oxygen of the air present, but has to do with the effect of free hydrogen on the iron of the cylinder and possibly on the layers of partly burned oil."

I believe coke oven gas to be the power gas of the future, in places where it is impossible to get blast furnace gas or natural gas, on account of its high calorific value, freedom from dirt and tar, and its adaptability to pumping great distances under pressure in comparatively small pipes.

AIR IN RELATION TO THE SURFACE-CONDENSATION OF LOW-PRESSURE STEAM: AN EXPERIMENTAL STUDY OF CONDENSER PROBLEMS.*

By JAMES ALEX. SMITH.

To some extent the present is a sequel to a former paper dealing with "Air in Relation to Boiler Feeds," read before this Institute on June 4, 1904.

The principal object is to contribute to the knowledge of an imperfectly investigated subject, fundamental data derived from direct experimental researches by the writer. The aim is to stimulate discussion and examination of hypotheses that have been accepted upon premises that are no longer sufficiently accurate to meet the exigencies of modern design.

The keynote is the effect of gases—specifically, atmospheric air—upon working efficiencies and capital investment.

The chief deduction is that air, even in minute traces hitherto considered innocuous, should be, by initial design and subsequent management, rigorously excluded from high-grade surface-condensing installations. Certain laws of condensation are also enunciated.

PRELIMINARY.

Steam engine practice is inferred throughout. The method of extending the deductions to the condensation of steam for potable water, or vapors for manufacturing processes, will be obvious.

Even a superficial glance reveals the inadequacy of the older data. First, because the trend is to expand steam to degrees undreamt of in the past, when those data were collected, and to reject it at temperatures so low that crude rules, simply embodying obsolete average conditions, are useless. Second, because it appears to be tacitly assumed that generalizations derived from incomplete investigations of pure steam are equally, and without modification, applicable to mixtures of steam and gas.

Experiment shows that such assumptions are fallacious, and that the presence of air in quantities that might have been deemed insignificant may, in fact, become the factor limiting the efficiency of a whole steam plant. For instance, air equal in pressure to only 1-20th of an inch by the mercury gage will, at 90 deg. F., reduce thermal transmission some 25 per cent, while 3-20ths will lower it about one-half. Before these special effects could be determined it was necessary to investigate the whole subject of surface-condensation.

EFFECT OF CONDENSER TEMPERATURE UPON ENGINE EFFICIENCY.

The necessity for dealing with the main issue will be inferred from an elementary analysis of the effects upon the thermal efficiency of the reduced temperatures aimed at. It must, however, be clearly understood that in the cases of engines, reciprocating or rotating, not specially designed to utilize these temperatures, it may be inadvisable to attempt their use.

* Read before the Victorian Institute of Engineers. Revised by the author.

	7·5 Atmos.					
	Syracuse Producer.	Detroit Producer.	Coke Oven.	Natural Pittsburg.	Natural Ohio.	Blast Furnace.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Hydrogen	7·77	8·16	4·60	1·50	0·13	0·00
Carbon monoxide	10·88	3·00	0·42	0·08	0·04	16·67
Methane	0·48	3·08	3·70	5·28	6·27	—
Ethylene	—	—	0·48	0·05	0·01	—
Benzene	—	—	0·10	C_2H_2=0·27	—	—
Carbon dioxide	4·03	6·04	0·18	0·06	0·01	7·09
Oxygen	0·09	0·44	0·02	0·08	0·03	—
Nitrogen	24·69	19·28	0·58	—	0·28	36·85
Air	52·06	60·00	89·92	92·58	93·15	39·39

When there is a notable fall in density between the points of release and condensation, the consequent increment of piston load may be incommensurate with the cost requisite to transmit the heat, at a lower temperature difference, to the cooling water.

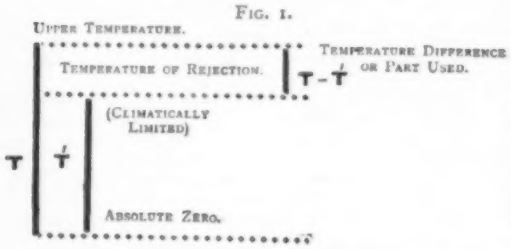
Modern practice differs in the cases of cylinders or their equivalents exposed alternately to hot and cold steam, in degree only from the old Newcomen method of injecting water into the cylinder. The question is one of compromise. Each instance requires individual evaluation, and in the cases alluded to, cylinder condensation, and reduced temperature of hot-well boiler feed, will neutralize vacuum effects pushed beyond a certain point. It is otherwise when steam can be expanded—constantly performing useful work—down to condenser pressure; then every consequent fall of temperature is accompanied by a corresponding gain in thermal efficiency. The reason that the road of improvement is by the way of reduced final temperatures is that energy in thermal form, or "heat," is the capital of the power engineer, and that the theoretical efficiency of any ideal heat motor, of whatever design, and whether using steam or any other medium, depends ultimately upon the proportion of that capital transformed into its equivalent of mechanical energy.

The thermal capital of a given mass is measured by its temperature referred to absolute zero, or —461 deg. F., and the efficiency of any ideal engine using the mass is determined by the ratio of the temperature fall (thermal capital used) to the initial absolute temperature. When T equals the initial, and T' the final absolute temperatures of use, this is expressed by the well-known equation:

$$\text{Efficiency} = \frac{T-T'}{T}$$

It is the ratio of the part used (fall, or difference of temperature) to the initial (capital) temperature. Graphically, it may be delineated thus:

FIG. 1.



The hydraulic analogue is a perfect turbine situated between an elevated water source and the sea. At the exact source level no power can be derived, at the sea all can be used. At intermediate points the effective head is that above the turbine, and the proportion of that to the whole potential head, referred to sea level, is the ratio of possible efficiency. It may be absolute if the turbine is at sea level, or if the source is at an infinite height. Similarly thermal efficiency may be absolute if the initial temperature is infinite, or if the final temperature is zero absolute. Of course both extremes exist in theory only, but approximation to the latter is, in practice, easier than to the former.

If the fractional expression $\frac{T-T'}{T}$ is examined in this connection, it will be observed that the denominator (T) is constant, while the numerator ($T-T'$) is variable. If, then, T' is varied by equal successive steps, a series in arithmetical progression results that may be typified by 0/10, 1/10, 2/10...10/10. Hence each equal decrement—utilized—of temperature causes equal increments of efficiency if the initial temperature remains constant.

The subjoined table shows the extreme desirability of utilizing to the utmost the lowest temperature consistent with the climatic environment, and this is only possible by perfecting the condenser.

Thermal efficiency in relation to the lower temperature limit.

Upper limit constant at 371 deg. F. (= 160 gage pounds of steam, nearly.)

Referred to the duty when rejected at 212 deg.

Lower Temperature Degrees F.	Differences.	Efficiency Increments. Per cent.	Differences.
140		45·27	
130	10	51·56	6·29
120	10	57·85	6·29
110	10	64·14	6·29
100	10	70·43	6·29
90	10	76·72	6·29
80	10	83·02	6·29
70	10	89·31	6·29

NOTE.—At 212, 140 and 70° the absolute thermal efficiencies are respectively ·191, ·218 and ·362. Graphed, both temperature and efficiency are straight lines.

PHYSICAL BASIS OF CONDENSATION.

It is not necessary that this phase should be exhaustively treated, but it is essential that the line of thought underlying the actual experimental work should be comprehended, although those who so desire may confine their attention to the experimental section of the paper, upon which the conclusions are based.

Steam or gases alike are masses that were, at a previous period of their physical history, fluid. They differ from liquid in that energy has been imparted to them in such a manner that the mean free paths of the component molecules between collision have been extended; as a consequence the volumes reserved by individual molecules have been increased, and, as a further consequence, the volume of the mass as a whole has enlarged. The rate of molecular motion is apparent as temperature, the rate of molecular bombardment upon unit area of the containing wall as pressure. Were steam contained in a vessel such that the molecules of that vessel completely restored to the steam molecules the energy of impact, then the steam energy would remain forever imprisoned and potential, if radiation through space free from non-ponderable matter be excepted—and in relation to condenser work it may be eliminated. If the coefficient of restitution is imperfect—as it always is—then a portion of the internal energy of the steam passes to the molecules of the walls, and thence to any interlinked cooler environment furnishing an energy sink.

Thus the original evaporation cycle is reversed. But in the case of each fluid that may become a recondensable vapor, or each vapor that may become a fluid, there is a sharp demarkation between the states. Given a vapor differing insensibly in temperature from that of its fluid at the same pressure, then it is at its critical point, and the slightest abstraction of internal energy through the walls of the containing vessel will determine the liquefaction of a portion, strictly in accordance with the energy transferred. Thus, in the case of pure saturated steam—that is steam at its critical point—in contact with an energy absorbing, or cold, surface, the most intense volume change, where the latent heat is given up, or the molecular paths alter in extent from that traversed as steam to that traversed as water, is immediately at the surface. The rates of increase of the paths of the relatively great numbers of residual molecules at any instant is relatively insignificant.

In the case of steam, given the energy sink, the chief limit to the rate of change is the time required for the internal energy existing as molecular motion in all directions to become, in part, energy of motion in one general direction of approach; in respect to the walls, it is the transmitting capacity of the molecules, that is the thermal conductivity of the solid.

"Permanent" gases do not even remotely approximate to their critical point at condenser temperatures. There is no selective reduction of a portion of the molecular paths, but a general (although slight) reduction of all as a consequence of cooling and the change is accompanied by a motion of approach negligible relatively to that of steam.

Logically it follows that the condensation of pure steam, and of steam mixed with a permanent gas with which it does not combine chemically, is radically diverse.

Steam progresses continuously toward the surface where it becomes water, passing away in that dense state, almost without resistance, as drops or a gliding film. The inter-diffused gaseous molecules are impelled toward the same surface, but in that direction they cannot escape.

Dalton and Graham's laws of partial pressures and diffusion make for homogeneity of mixture, but they are rigidly true only when the volume is statically constant; here the conditions are dynamic. The result is ultimate equilibrium, but not homogeneity.

Since the steam condensation is chiefly evident in a thin lamina of minute thickness, at the condensing surface, it follows that, given a moderately rapid motion of general approach, then, although the gas may at first be highly tenuous, a very slight retardation of diffusion may permit of an accumulation of molecules at that laminar focus of energy change, when their impedence is a maximum.

To qualitatively study some of these phenomena the author uses closed glass tubes containing bromine, both with and without air in the vapor space. The low boiling point, deep non-actinic color of the vapor, and strong russet-red of the condensed films, render it easy to follow the processes of diffusion and condensation and photograph the results.

BASIS OF EXPERIMENTAL RESEARCH.

Clearly the fundamental basis of investigation is a study of the retardation of diffusion of gases entrained in steam possessing motion of translation in space.

The question when complicated by the conditions essential to practice is most complex, and it did not appear that there were sufficient data to permit of mathematical solution, therefore it was determined to investigate the various phenomena experimentally. This was found to entail a very considerable amount of work before non-essentials could be eliminated.

Quantitative records to be reasonably accurate require that the exact temperatures and partial pressures of the steam and gases, the temperature and mass of the cooling water, and the condensing superficies shall be known and shall be constant, or variable at will. The rate of metallic thermal transmission, gaseous solution in fluid, gaseous thermal conductivity, and other matters must either be determined or eliminated.

It is hopeless to expect that these requirements can be met by experiments upon condensers in actual use, although such tests have great value in other directions. It was decided to deal with the matter on a scale that permitted the omission of non-essentials while retaining in isolated form those functions approximating as closely as possible to the essentials. After considerable tentative work, necessitating some hundreds of tests, the author rested in the construction and methods to be described.

The experimenter should in a matter of this nature possess previously-acquired manipulative skill—especially in thermometry—and should familiarize himself with his apparatus until that manipulation becomes instinctive and sure.

No attempt has been made to deal with abnormal states of scale or oil films. In practice such uncertain, possible conditions are met by a large excess of surface at enhanced cost. Higher future efficiency of standard plants should raise the ideals, and, even by a purely imitative process, minor plants should be improved in these respects.

Essential Conditions.—With a finite condensing surface, and a constant rate of flow of cooling water over that surface, the water temperature increment is the basis of the relations sought. To enable the information to be gleaned, and the variations to be codified, the following experimental conditions must be attainable:

(a) Partial vacua within the range of probable condenser practice.

(b) Any relation of steam to gas partial vacua.

(c) The various constants not to be affected by the progress of the experiment.

(d) Temperatures and pressures to be controllable with considerable exactness.

(e) Constant flow of cooling water at a pre-determined rate and temperature.

(f) The temperature of flow to be determinable at points intermediate between the initial and final.

APPARATUS.

Generation of steam in a vessel distinct from the condenser is inadmissible when vapor mixtures are in question. The equivalent of an indefinitely great vaporous atmosphere of constant composition is required. If a separate boiler is used, whatever the original composition of the mixture, the continual

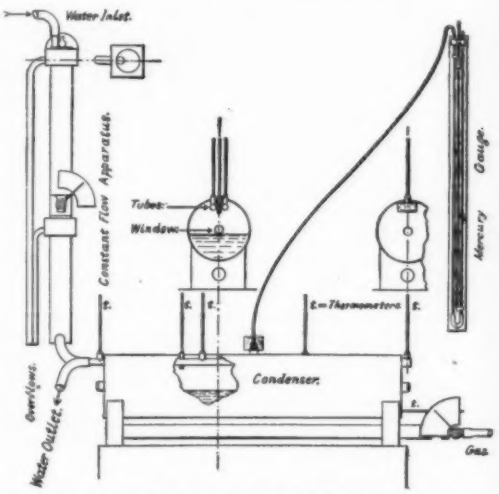


FIG. 2.—GENERAL ARRANGEMENT OF CONDENSING APPARATUS.

Note—In actual use the constant flow apparatus is placed at a higher level.

unidirectional flow of the steam will cause a varying and unknowable concentration in the condenser. If the condensed water accumulates the condenser volume and vapor distribution will vary; if drawn off a complication of apparatus follows, with great danger of air admission; further, absorbed gases will be withdrawn in aqueous solution to an appreciable amount during a long series of tests.

In the apparatus before the Institute, and illustrated by Fig. 2, the condensing tubes pass through the steam space of a boiler and constancy of the condition of the mixture is practically complete.

Containing Vessel.—Length about 3 feet 0 inch, diameter 7½ inches; No. 19 B. W. G. galvanized sheet steel, strengthened by one central ring of 1 inch x ¼ inch steel. Intentionally made light in order that temperature lag may be minimized. The joints are folded, soldered, and tarred. This must be carefully done; it is most difficult to completely exclude leakage; solder alone will not do so. By leakage is meant the admission of sufficient air to reduce the mercury gage level say 1-50 inch in 24 hours.

At either end there is an axial opening glazed for observation by slightly taper glass plugs with polished plane faces. The plugs are cores cut from ¾-inch polished plate glass by a rotating brass tube and 70-hole carborundum; the joints are made tight by sleeves of pure rubber tube smeared with melted rubber and then inserted with the plugs in slightly conical brass tubulatures. A small stop-cock, with a ¼-inch shank screwed into an opening in the shell, is the only other non-positive sealing, and this is inclosed in a vessel of water to prevent air ingress. Connection is made to the gages, etc., by sound, new, thick walled rubber tubes of 1-16 inch internal, and ¼ inch external diameter.

Heating Arrangements.—In the first types of apparatus boiling was effected by steam passed through internal tubes, the intention being to measure the steam condensed. It was found that numerous corrections and adjustments rendered an apparently simple system uncertain; subsequently heating by gas

was adopted, and is quite efficacious. A horizontal mixed air and gas tube of 1½ inch diameter extends beneath the whole length of the containing vessel; it is perforated by 60 apertures in two rows; each jet is ⅛ inch diameter. The temperature is adjusted and maintained constant by varying the gas by a stop-cock with a pointer attachment traversing a graduated quadrant. This, with a pressure regulator in the service supply, is sufficient to insure constancy to 1-10 degree. Gas up to 45 cubic feet per hour is necessary.

Condensing Tubes.—There are two of these connected in series. Each is a little more than three feet long; the total effective length is therefore rather more than six feet; the external surface exposed to the vapor is exactly one square foot. The external diameter is about ⅝ inch, the thickness is 0.018 inch, and the sectional area of the bore is 0.26 of one square inch.

The tubes are hard, mandrel-drawn brass; the surface is a draw plate one, clean and smooth but not polished in any way. The thermal conductivity depends upon the thickness, chemical composition, and physical state of the material of the tube, and the temperature and mass of the flow. To avoid the difficulty and uncertainty of determining some of these factors, the whole were conjointly dealt with by passing water at 32 deg. from melting ice at the rate of 5 pounds per minute through a piece of tube cut from the same length as the main tube, and surrounded by pure steam at 212 deg. F.

The short tube was one-tenth of the length of the condensing tubes, and exposed one-tenth of one square foot of cooling surface. Sixty-seven B. T. U. were transmitted per m., and this supplies the basis for comparison for other metals and states.

At each foot of effective length a perpendicular branch tube penetrates (except terminals) through the steam space and shell. Through these a small-bulbed thermometer can be inserted through a cork jacket into the main tubes, in order that intermediate temperatures can be ascertained. Long cork plugs, flush with the tube bore, close the openings when not in use.

Constant Flow Apparatus.—It is necessary that the rate of flow shall be adjustable, and that it shall be accurately measurable. The constant flow apparatus (Fig. 2) was devised to this end and answers perfectly.

It consists of a vertical tube, closed at the bottom, into which an excess of water is delivered by a perforated tube in a non-eddying manner; the excess escapes over the upper lip. A stop-cock (with carefully-polished ports) together with a long pointer and graduated arc, allows definite flows to be drawn off and discharged into a second tube connected with the condensing apparatus. The graduations were made at each 2½ pounds per minute, from 2½ to 20 pounds, and were carefully and repeatedly calibrated by weighing the discharges during 10 to 60 minutes.

Vacuum Gages.—Various types were tried; the difficulty is the deposition of condensed vapor. Closed U gages—barometer and gage combined—give direct readings but soon lose accuracy from the creeping of the water film into the torricellian space. To substitute a known for this unknown variable, water was introduced in excess, also a large chamber containing a perfect water vapor vacuum was attached, and the corrections for temperature made. Ultimately a simple open U gage, shown in Fig. 2, was adopted. No capillary correction is necessary, and with thin glass parallax is negligible. The mercury must be pure.

Barometer.—The form of gage used requires the use of a comparison barometer. In order that the readings shall be true, the tube is filled with pure mercury, and this was boiled thoroughly in place.

Thermometers.—These were carefully checked against a reference instrument itself compared with instruments certified by the Imperial German Testing Laboratory. The Victorian government astronomer (Mr. P. Baracchi) also kindly compared one of the instruments with his standards.

Note.—Purchased instruments can be regarded only as arbitrary and, perhaps, irregular scales until the necessary corrections have been ascertained by comparison with an assured standard, or gas thermometer. They may be very considerably in error from a number of causes, so also may barometers. The only security is to construct or calibrate them personally or supervise the work, unless the investigator can obtain them direct from a maker of repute together with a certificate of performance.

(To be continued.)

GELATINO CHLORIDE EMULSION FOR GASLIGHT DEVELOPING PAPER.

By A. J. JARMAN.

THE demand that has been created of late years for papers that can be printed and developed under artificial light has caused questions to be repeatedly asked as to whether a person could prepare these papers himself, and is there a good reliable formula, or formulæ, for an emulsion that can be used for the purpose. The object of the present article is to fulfill that requirement.

A few utensils will be required to carry out the work of making the emulsion; but these are not expensive. The point of paramount importance in this matter is strict cleanliness in every operation and avoid the entrance of all actinic light. Given that these points are attended to there will be no need to fear non-success. In all the operations of preparing emulsion, distilled water of reliable quality only must be used.

Obtain one or two stoneware crocks fitted with lids; clean these thoroughly with hot water; wash them out with a good supply of clean cold water, stand them to drain upon a clean cloth or towel, or upon clean blotting paper. As soon as dry, proceed as follows for a small quantity of emulsion:

Hard gelatine ("Heinrichs")	2 ounces
Distilled water	10 ounces
Chloride of ammonium	108 grains

Allow the gelatine to soak for a short time. It is best to cut the thin sheets of gelatine into strips with a pair of clean scissors. This will permit of its lying flat in the water. Place the crock containing the above into a large saucepan with water standing up about three inches around the outside. Heat the mixture until all the gelatine has dissolved, stirring with a clean strip of glass or a glass rod. The water in the saucepan may be brought up to boiling point, so as to insure the complete dissolving of the gelatine. After this the crock should be allowed to stand until the temperature of its contents has become 130 deg. F. Then under a ruby light the following acid solution of nitrate of silver must be added, which should also be made warm, about 120 deg. F., heated in a glass flask:

Distilled water	10 ounces
Nitrate of silver	252 grains
Citric acid (powdered)	30 grains

This must be added to the gelatine mixture slowly, and the whole stirred vigorously during the addition. As soon as the mixture is complete the crock can be cooled off rapidly, taking care to cover the top with black paper, and tying it so as to preclude the entrance of any white light. As soon as the contents has become thoroughly cooled and set, the jelly or emulsion must now be broken up and mashed, so as to get rid of the nitrate of ammonium that has been formed, and forms the principal salt of decomposition. This is accomplished by removing the lid under a ruby light and using a piece of mosquito netting or coarse canvas, such as is used to work woolen yarn upon with about an eighth of an inch mesh. Cut a piece about eighteen inches square, wash it well in warm water, then in cold, and place a piece of the solid emulsion in the center, having previously half filled the crock with clean cold water, leaving the balance of the emulsion at the bottom. Now twist up the cloth, hold the piece of emulsion firmly in the grip of the left hand, then twist the cloth with the right hand until the emulsion has been all squeezed through. Treat the whole of the solid emulsion the same way, when it will be found that the shreds formed by the wringing process present very much the appearance of boiled rice and become well washed by a dozen changes of water. Tie over the top of the crock the same cloth folded twice, so as to form four thicknesses. This done, turn the crock upside down, allow the water to drain out well, turn the crock over, and pour in another three or four pints of cold water; shake the crock round and round; allow to stand a short time; then drain again. This must be done repeatedly for a dozen times. Then the crock may be inverted and allow the draining to take place for half an hour. The emulsion may then be considered washed, and is ready for melting and coating.

For coating the paper proceed as follows: Place the crock with its contents into a saucepan of hot water. Allow the crock to stand upon a piece of wood, increase the heat nearly to boiling point in the saucepan; lift the crock, occasionally shaking it round and round. In a very short time the contents will be all melted. Uncover the crock under ruby light and add one ounce of pure alcohol, stirring with a glass rod at the same time. Now filter through a clean kerosene lamp chimney by tying over the narrow end a couple of thicknesses of washed-out cheesecloth. Cut off the spare edging with scissors. Then press down in the interior a tuft of absorbent cotton. Place the chimney inverted in a hole made in a shelf or the ring of a retort stand. Place a clean stoneware pitcher beneath. Then pour the hot emulsion into the lamp chimney. By this means the filtering will be conducted perfectly. All thick and viscous liquids are best filtered by the above plan.

Now take some sheets of paper, either rough or smooth, or both. Paper such as is used for albumenizing and some of the usual drawing papers will do. Cut them into strips, say eight or ten inches wide and two feet long. Grip the ends with thin strips of wood and three wooden clips at each end. Have these in readiness. Pour the emulsion into a clean 10 x 12 tray. A porcelain tray is good for this operation. Now take one of the sheets of paper; bend it like the letter J; dip the lower end down upon the emulsion; gradually raise the left hand, lowering the right at the same time, so as to admit of the paper passing over the surface of the emulsion—say twice. Then drain from one corner against the edge of the tray for a moment. Now raise the sheet and wave it to and fro a short time. The emulsion will soon become set, when it can be suspended to dry in a clean darkened room, away from dust. As soon as dry, it is ready to cut up to the required sizes for printing and developing. The balance of the emulsion, if any, may be put aside and used the following day. Plates may also be coated with the same emulsion, which produce extremely fine transparencies for the lantern.

Developing may be conducted with any of the developers for gaslight papers, or the following will answer the purpose, which may be further diluted and modified by the addition of a few drops of a 10 per cent solution of bromide of potassium to suit:

DEVELOPER.

Metol	20 grains
Hydroquinone	40 grains
Distilled water (warm)	15 ounces

Dissolve the above and add thereto 140 grains of granulated sulphite of soda; shake the mixture well; add 120 grains of granulated carbonate of soda and 17 ounces of cold water; also add 32 drops of a 10 per cent solution of bromide of potassium (made by dissolving half an ounce of potass. bromide in five ounces of water). Shake the mixture well. As soon as quite cold it is ready for use. A different color is obtained if 30 grains of metol and 30 grains of hydroquinone are used, the developer being more energetic. As soon as development is complete, wash the print slightly and fix in

Hyposulphite of soda	4 ounces
Water	20 ounces

Add to this when the hypo has dissolved half an ounce of powdered alum in 10 ounces of water and half an ounce of commercial acetic acid. The image will fix in ten minutes, when it should be well washed for a quarter of an hour, when it can be dried, trimmed and mounted. A more rapid emulsion is produced by placing the citric acid in with the gelatine and treating the nitrate of silver solution with ammonia, drop by drop, until the oxide of silver which is formed is only just dissolved. In this case use only 9½ ounces of water to dissolve the nitrate of silver in. When mixing, add this ammoniacal nitrate of silver in place of the plain solution. The emulsion will be found upon examination to be perfectly grainless; so for transparency making it will be found to be admirably suited, and also for the coating of postcards and other similar material.

REMARKABLE HUMAN BONES IN A NEBRASKA MOUND.*

IN a mound near Omaha, Neb., have been exhumed some human remains which seem likely to attract more than passing attention. The finder, R. F. Gilder, has been interested in the archæology of the Missouri Valley and the region beyond, and has previously unearthed at various points numerous objects of interest and value. In this case the remains were found in a mound located on a conspicuous hill crest, and are unusually well preserved. Mr. Gilder reports that in a cleared area some thirty-five feet in diameter, the skeletons had been arranged so that two were in a sitting posture and the others recumbent with heads to the center and bodies radiating therefrom. From the positions of the bones it appeared that the flesh had been stripped off before the skeletons were placed on the area, although no marks of a tool have yet been found on the bones. Once placed, these bones were covered over with clay to a depth of eighteen to twenty-four inches, and a fire was built upon the top. The layer of ashes was later covered by earth which had been scraped up with shells, and the fragments of the shells are still demonstrable in the earth mass. The latter now measures some four feet in thickness. It is, of course, apparent that the half-baked clay would serve as an admirable protection from the destructive elements, especially in view of the naturally perfect drainage of this location. A small triangular flint knife and a number of fine pink quartzite spalls are the only other objects found in the area excavated.

None of the skeletons is complete, and many of the bones are imperfect, yet some peculiar features are apparent on first examination. Most striking of all is undoubtedly the lateral aspect of the cranium. The supra-orbital ridges are massive and prominent, while the frontal bone slopes almost directly backward in a way which forcibly recalls the most primitive human crania yet discovered. The lower jaw is abnormally developed, its muscle attachments are prominent, and the teeth, even the usually unused third molar, are worn down to the gum. The bones are heavy, and their muscle attachments strongly developed, while both femur and ulna display a marked and peculiar curvature forward. In fact almost every part of the skeleton departs from the type of the human skeleton of to-day in some particular, and in general these differences indicate a more primitive type. The exact bearing of these peculiarities will be clearer after the completion of the detailed study of the bones already begun by Profs. Erwin H. Barbour and Henry H. Ward, of the University of Nebraska, to whom the specimens have been intrusted for exact measurement and comparison with recorded data.

Of the importance of this discovery there can be no doubt, even though its significance is not clear at this moment. The remains are not readily referable to any known aboriginal race of this continent, but before the completion of exact comparative studies all speculation as to the age of the remains, the character and habits of the people they represent, or their relation to later known tribes, appears somewhat premature. This find, together with others important but less widely known, and with some yet unpublished discoveries regarding the remains of prehistoric man in Iowa, Nebraska, and westward, indicate clearly that the thorough examination of this region will add much to our knowledge of early races on this continent.

* Nation.

HOW SEEDS ARE CARRIED.*

I. SEEDS THAT FLY.

By CRAIG S. THOMS.

IT is difficult to find a square yard of soil in which under proper conditions of heat and moisture seeds of some kind do not sprout and grow. Fields left fallow have no lack of weedy crops; river beds abandoned by their streams for other channels—as sometimes occurs with the Missouri—are found in a year or two clothed with young willows and cottonwoods, besides weeds and flowers of many kinds.

Plants imported accidentally from the Old World, like the Russian and Canada thistles, soon spread over a large part of the country. Occasionally a plant appears in one section whose habitat is in another. How are the seeds carried?

For convenience we have grouped the subject under four heads: I. Seeds that Fly. II. Seeds that Tumble and Float. III. Seeds Carried by Animals. IV. Seeds Propelled by Plants. Each of these divisions will require a separate article.

Certain very minute seeds, such as those of fungi, are so light that they float in the air without special apparatus for that purpose; but most seeds that fly have special contrivances to bear them up—usually either a pappus or a wing.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

SEEDS WITH A PAPPUS.

The familiar dandelion doubtless has the most beautiful pappus that grows. Who when a child has not picked a ripe head and placed it before his mouth, to see if he could blow off every pappus at a single breath? On a dry day the white, fibrous head is expanded into a perfectly round ball, and the gentlest breeze picks off a few seeds at a time and carries them away. On a wet day, however, the parchment-like top to which the seeds are attached shrinks, and the seeds with their pappus are pressed together, and held fast until another dry day causes the grip to be relaxed.

This habit of gripping and holding seeds on wet days is not peculiar to the dandelion. The thistle has the same habit; and even on dry and windy days it does not fully expose them, for the seeds are heavy in proportion to the buoyancy of the pappus, and a wind of considerable force is necessary, not only to dislodge them, but also to carry them.

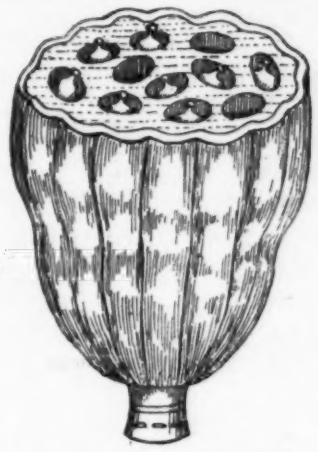
One plucking thistle pappus from the spiny head notices the slender grip which the pappus has upon the seeds. This explains in part why thistles are so frequently found along stone walls, hedgerows, or other fences. The jar of striking severs seed from pappus.

Through most of the winter months the goldenrod stands with dense, furry heads. The pappus is not large in proportion to the weight of the seed, and it requires the fiercest hurricanes of winter with their peltings of snow to send all the seeds afloat upon the air; but in such hurricanes, of course, the seeds are driven far.

On the other hand, the milkweed pappus, with filaments so fine and silky, and so ample in proportion to the weight of the seed, that a wave of the hand above it in a still room will send it flying to the ceiling, does not require a windy day for its distribution, and so when once its seed pod has opened it does not again grip its seeds, but remains wide open, no matter what the character of the day.

In the dandelion pappus, spreading filaments crown one end of a central stalk, while the seed is attached to the other; in the pappus of milkweeds, thistles, goldenrods, and many others, the whole bunch of pappus is attached directly to the seed; a third type of pappus, and a very interesting one, is that of the cattail. The seed, instead of being attached to the base of the pappus, is attached to the farther end of its central filament. With this arrangement the weight of the seed causes the pappus filaments to open out like a parachute. Since, however, in the case of the cattail the seed is so small and light that the least breath of air carries the pappus, no matter what its position, this special arrangement would seem to find its significance in relation to water, near which or in which the plants

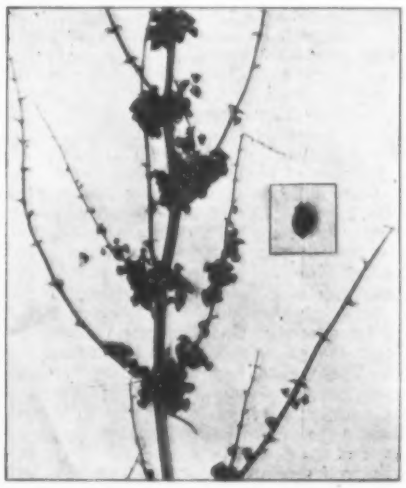
WILD CLEMATIS SEED CLUSTERS, SHOWING THE LONG STRINGY PAPPUS.



SEEDS AND SEED POD OF THE LOTUS.
(Drawing by Sheridan Janes.)

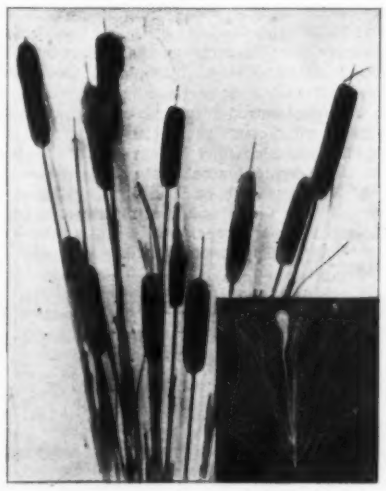
RAGWEED. TO THE LEFT, THE BARE SEED CAPSULE; TO THE RIGHT, SEED CAPSULE WITH ACCIDENTAL WING.

WINGED SEEDS OF THE BOX ELDER, SHOWING WING AND SEED ENLARGED.



THE DOCK SEED IS WINGED.

SEED POD OF THE PINE, SHOWING ENLARGED WINGED SEED.



THE MANY-SEEDED CAT-TAIL AND ITS ENLARGED PAPPUS.

grow. By experiment one will find that the center of gravity of this pappus with its seed is such that when in water it lies on its side with the filaments spread out toward the seed. The fruit is very firmly attached to the central stalk, thus rendering a severance of the fruit from its pappus very improbable.

Both of these facts are significant. Though one hundred thousand seeds would doubtless be a conservative estimate of the number on a single cattail head, only those grow which find lodgment in swampy places, on river borders, and lake margins—the habitat of this plant. The wind blows a large proportion of cattail seeds into deep water of lake and river, where, by force of the waves, seeds lightly attached to their pappus, like those of the thistle, would become detached, sink, and perish. But the cattail fruit, since it clings to its pappus and is so balanced that it floats, is carried to margins and coves where it becomes imbedded in the mud and grows.

A similar arrangement of pappus is seen in the seed balls of the sycamore, which cling to the tree all winter and distribute their seeds in the spring. The pappus is attached to the small end of the long, wedge-like seed, and points to the large end, hugging the sides of the seeds as they stand pressed together in the ball. In proportion to the size of the pappus, the seed is large and heavy; but when thrown into the wind the heavy end turns downward and the pappus, like that of the cattail, spreads out like a parachute. The height of the tree, of course, gives these seeds an advantage, since, in a strong wind, the fruit without any pappus would be carried to a considerable distance.

Another arrangement is that found in the Virginia anemone, where the pappus filaments are attached to all parts of the seed, leaving the fruit in the center of an irregular, fluffy, cottony ball, which not only permits it to be borne away triumphantly by the wind, but also to attach itself to the fur of animals that rub against it in passing.

Still another type is found in the long, hairy strings of the clematis, each one attached to a single seed. This arrangement is much more effective for its purpose among trees and brush, where the clematis grows, than would be one of bulkier sort like that of the milkweed. To be sure, the clematis pappus catches upon brush and twigs, but its single, stiffish string is not apt to become tangled and fastened until it has reached its destination.

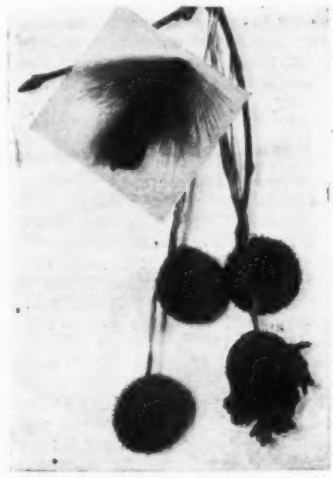
SEEDS WITH WINGS.

The different arrangements of winged seeds is one of the most interesting studies in botany. In all of them there is an element of action which the pappus does not possess, and the inventor could do much worse than to take lessons in this field of devices.

It is a well-known principle of mechanics that a whirling motion is a great aid in supporting objects of certain shapes as they pass through the air. This is the principle utilized by nearly all winged seeds. As in the case of pappus, there are a number of well-defined types, though with almost infinite variations.

Some wings are attached to whole seed-clusters. Of this type the linden is a good example. From the center of a large wing the cluster of seeds hangs by a single stem. As the wing dries it becomes slightly turned up at the larger end, and also so twisted that the wind gives it rotary motion. It is the upturned end that is especially effective in carrying power, since in turning it constantly strikes the air at a higher plane than the rest of the wing, and tends to bear the whole up; yet the weight of the seed cluster is so great in proportion to the size of the wing that the seeds are not carried to any great distance.

A more common type is that in which the wing is simply an extension of the seed pod. The silver maples, box elders, and ashes are familiar examples. These winged seeds hang in open clusters, each one attached by a small, short stem. In a strong wind on dry days, their brittle stems break and the seeds are whirled away one by one. The device is so balanced



SEEDS OF THE SYCAMORE, SHOWING PAPPUS ENLARGED.

that as it sails through the air the wing whirls rapidly round the seed as an axis, and the wing is so shaped and balanced that its front edge strikes the air higher than the rest of the wing, thus producing air pressure in an upward direction. I have seen these seeds, when dislodged from the top of a tall tree in a fair wind, go more than thirty paces.

The seeds of ashes and box elders cling to the trees

WHAT A WINGED SEED CAN ACCOMPLISH.

in winter and are often driven to considerable distances in fierce gales.

Certain trees also have winged seeds which are inclosed, as the pine in cones, and the catalpa in long seed pods. If one bring a closed pine cone into the house in winter the heat and dryness soon cause the cone-scales, with a sharp, snapping sound, to burst apart, revealing the winged seeds lying between them. Place the cone in water and the scales close again. On dry, windy days one may hear the popping of the pine cones and see the delicately winged seeds sail out upon the air. In wet days—days unsuited for successful seed flight—the cones close.

SEEDS OF THE COMPASS PLANT, SHOWING HOW THEY ARE BLOWN OFF BY THE WIND. AT THE LEFT IS SHOWN THE SEED WITH AND WITHOUT WING, AND BETWEEN THEM THE PECULIAR WING TURNED BACK.

Another type of wing, a type which impresses one as being extemporized, is seen in hops. The roundish seed is simply tucked in the basal corner of a large leaf (fruit scale), the leaf acting as a wing to carry it in winter winds.

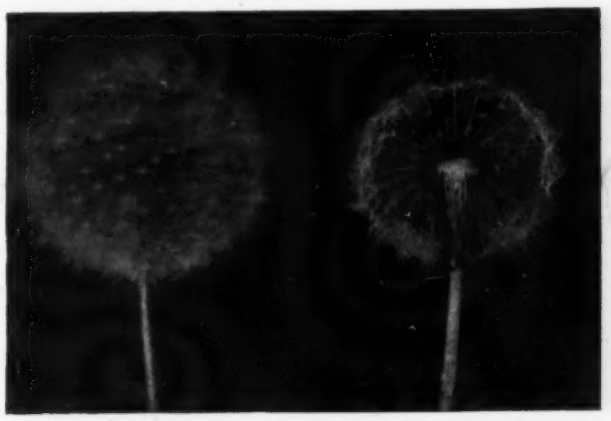
In certain plants, while there is no wing extended markedly in one direction, the seeds, which are usually flat and light, are winged all about by a broad margin of seed-covering. Good examples of this type are *Yucca glauca*, or bear-grass, and the compass plant (*Silphium laciniatum*), or, as we used to call it in boyhood, "gum-weed." The yucca has closely packed into each of its large pods more than four hundred and fifty thin, black seeds. At one corner there is an upward tilt of the margin, and if the seed be let fall from the hand it will often obtain a rapid whirling motion before reaching the ground.

The compass plant seed, while having a broad margin, has also a peculiar narrow wing attached to one end, extending lengthwise across the back, and protruding slightly beyond the base of a notch at the other end. It is not easy to understand how this wing acts, but its effect, when the wind by blowing between the two wings makes them spring apart, is evidently to bear up the smaller end of the seed, to which the small wing is attached, thus answering the same purpose as the upturned corner of the yucca.

Still another type of wing is that of the dock. Three thin, roundish wings, each bearing an outer callus, are pressed upon three sides of a triangular seed, thus holding the seed at their center. The three light wing margins are thus double, and in the gales of winter carry the inclosed seed to considerable distances, though doubtless the seed is upborne more by the lightness of the wings than by any circular motion which they acquire.

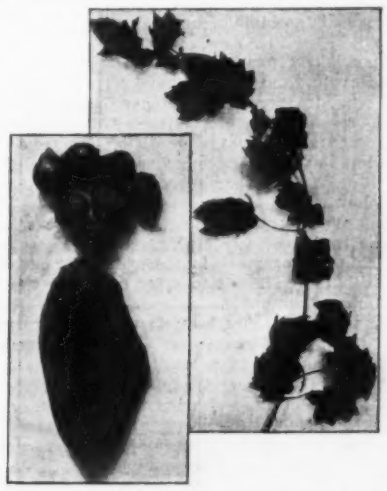
A very peculiar wing, one which almost seems accidental, is found in the common ragweed. Upon the outer end of the top-like seed are horny protuberances—a large central one, and about it a single row of smaller ones near the margin. Small leaves (or, to be more accurate, large, thin, irregular bracts) grow around each seed. As these leaves dry, some of their tips turn in and over the horns, thus holding in the seed. During the winter the seeds and leaves are blown away together, and the leaves help in the carrying process.

Some of the lighter seeds, especially those that are carried by pappus, are often caught in upward currents of air and carried very high. In this way seeds are lodged on mountains, cliffs, and rocks which could not be reached by the assistance of horizontal air currents.



THE DANDELION PAPPUS—THE MOST BEAUTIFUL THAT GROWS.

(To be continued.)



SEED CLUSTERS OF HOPS—EXTEMPORIZED WING AND SEEDS ENLARGED.

Present practice with modern boilers reveals the astonishing fact that the average evaporation amounts to from 2½ to 7 pounds, rarely more, and, say, exceptionally to 10 or 12 pounds of water per square foot of heating surface per hour. Until this rate is very much increased, boiler-house plant cannot be considered as worthy to rank alongside present-day engine-room equipment.

[Concluded from SUPPLEMENT No. 1611, page 25808.]

THE ADVENT OF SINGLE-PHASE ELECTRIC TRACTION.*

By C. F. JENKIN.

I now proceed to describe, shortly, the general arrangement of a single-phase equipment, and then to point out some of the more interesting problems which arise in practice, and to show how they have been solved.

The equipment of the line is very similar to the well-known continuous current tramway arrangement. A single copper trolley wire is suspended over each line of rails, and as all the wires over parallel or crossing lines of rail are at the same potential, they may be connected, the only insulation required being between wire and earth. The current is collected by means of bow collectors, which slide under the trolley wire; and as all the wires are at the same level at junctions, the bow slides freely from one to another without attention. The return current flows through the rails. Power is supplied to the trolley wire from feeders when the length of line requires them. Voltages of 3,000, 6,000, 10,000, and 15,000 for the trolley wire are already in use, and 20,000 has been successfully used experimentally in Sweden. The feeders may be at any voltage; they can be carried as bare wires on the poles. Thirty thousand volts is being used for feeders at Hamburg, with stationary transformers to reduce feeder voltage to line voltage. The power may be supplied from one or more power stations, and may be generated as single or polyphase current; but if polyphase generators are used, the phases must be kept separate and used for different sections of the line, which is usually troublesome.

The motor cars are equipped with one or more motors, each of which is fed from a transformer in the car, which reduces the trolley pressure to a moderate one—between 300 and 500 volts. The speed is controlled without loss in resistances by varying the voltage supplied by the transformer, or by a combination of this method with a variation of the excitation by means of a small auxiliary transformer.

The switching is done by means of contactors operated directly by single-phase magnets, or by compressed air controlled electrically. The rest of the car equipment is similar to continuous-current plant —master controller, reverser, automatic main-switch, etc.

Braking can be done by means of the motors, with the addition of resistances; but so far no simple method has been devised by which the motors can return power to the line. The auxiliary services of lighting and heating are very easily provided for, any voltage being available. Low-voltage lamps do not flicker perceptibly with periodicities as low as 25 or even 15.

Turning now to the details. The overhead line construction has none of the difficulties connected with the third rail, the awkward gaps which occur where rails cross being no longer necessary. The common tramway trolley line hangs in curves, so that there is a more or less sharp angle at each point of support. These angles are somewhat reduced by the lift given to the trolley wire by the bow, but they cannot be made nearly straight. It is therefore obvious that the collector bow on a car can only follow these curves when moving very slowly, since the sudden change of direction of motion at the point of support will require a large force to produce it eve at moderate speeds. There is always, therefore, more or less of a blow as the bow passes the supports, and the combination of the bending and the blow at the point of support results in frequent breakages. Statistics show that trolley wires break at the rate of about one per day in England, notwithstanding careful inspection and renewals. For high speeds it is therefore necessary to support the trolley wire in an approximately straight line, and only to vary its direction very gradually, and many arrangements for this purpose have been designed. Modifications of the catenary suspension have so far been the most successful, and one of the new designs is so simple that it leaves very little to be desired.

In its simplest form the trolley wire is hung at short intervals from the catenary wire by means of vertical wire droppers. The catenary wire is strained tight to prevent side swing. In this design temperature variations produce large distortions, and it is difficult to adjust the large number of droppers so that each will take its proper share of the weight of the light trolley wire.

An improvement on this is the use of two catenary wires, the trolley wire being hung between and below them. This arrangement is much steadier sideways, but is still more difficult to erect owing to the very large number of droppers.

The latest design goes back to the single catenary, but gives it a considerable sag, so that temperature distortion is reduced to a small amount. Under the catenary is hung an auxiliary wire by means of a few vertical droppers, and from this the trolley wire hangs by means of little loops, all of the same size. By this arrangement the number of droppers to adjust is reduced to one-quarter the number in the double-catenary design, and, as the weight on each is also four times as great, the adjustment is much easier. The small loops are spaced about 10 feet apart, and the trolley wire is sufficiently stiff to hang from these as a continuous girder, taking no permanent kink at the points of support. As the bow travels along it lifts a short length of the trolley wire a few inches; this is allowed for by the loops which rise off the auxiliary wire, and thus a beautifully smooth motion is obtained. A further advantage of this design is that the trolley wire is free to slip end-ways, and can be strained up without dragging the droppers out of the vertical. To prevent sideways swing the auxiliary and trolley wires are stayed to each post. On the clear line the catenary may be supported on poles with side-arm brackets, or on light beams supported on poles at each side.

In England most bridges are so low that the catenary construction cannot be carried through under them. The catenary wire may then be anchored to the bridge, and the two other wires taken through; these may be supported on short-span wires fixed against each face of the bridge, with additional span wires every 20 feet under the arch if the bridge is long. In tunnels there is sometimes room to carry the ordinary construction through; but if not, a construction like that under bridges may be used. Rigid conductors might be used, but for high speeds the elasticity of the trolley wire is advantageous. In stations the overhead construction can often be suspended from the roof.

The trolley wire must be divided into sections to enable faults to be located and cut out without interfering with the whole system. The design of a satisfactory section insulator for high voltage is not easy, so several methods have been devised for sectioning the line without the use of a mechanical section insulator. The simplest method is to anchor the ends of adjacent sections side by side, so that they overlap a short distance, arranging the levels so that the bow slides off one and on to the other smoothly.

Return Circuit.—The rails are used as the return circuit with copper feeders if necessary. As the rails are made of magnetic material, the skin effect makes their resistance to alternating currents much higher than their resistance to continuous currents—usually three to six times as high; but the currents are so small that this disadvantage is not serious. The resistance to alternating currents is not a constant, but depends on the periodicity and current. The return circuit is far from being non-inductive; therefore the drop of volts depends not only on the resistance, but also on the self-induction of the circuit. The whole drop, due to both resistance and induction, may be kept as small as is desired by means of small sucking transformers, which suck the return current out of the rails into a return feeder. All danger from shocks from the rails may be avoided by using earth plates connected every one-half mile or so to the rails. This procedure may be safely used in long lines which run mainly through the country, but is less suitable for the parts of the line running through towns; these are, however, usually short. Electrolysis has so far given no trouble with alternating currents, and it is not likely to do so except in special cases; there seems, therefore, to be no reason for keeping the drop of volts very low on long lines. The sample on the table is a piece of the earth plate from the Murnau-Oberammergau power station, which has been in use for 20 months; it is estimated that it has passed 7,500 ampere-hours. The corrosion is inappreciable.

The current flowing in the power circuit, i. e., the trolley wire and the return, consisting partly of the rails and partly of the earth, will produce interferences of three kinds on neighboring telegraph and telephone lines. To simplify the description of these let us consider a concrete case of a telegraph line on poles running the whole length of the railway. The first effect produced by the power circuit is due to the difference of volts between the earth plates at the two ends of the line, which will produce an alternating current of the telegraph line if, as is usual, it has an earth return. This can be prevented by using an insulated metallic return instead of the earth. Assuming that a wire for this purpose has been erected, the second effect will be that due to the mutual induction between the power and telegraph circuits. This effect is comparatively small, and will not be sufficient to affect the ordinary block instruments on lengths of line corresponding to ordinary block sections; it will, however, be important on longer lines. It can be approximately eliminated by twisting the telegraph circuit. Both of these effects are functions of the current in the power circuit, and are independent of the pressure.

By slightly modifying the ordinary telegraph instrument it is possible to continue to work with the earth return, and thus avoid the expense of the metallic return. Mr. Dahlander, chief engineer of the electric traction department of the Swedish State Railways, has very kindly given me permission to describe two methods which he has successfully used for this purpose. In the first the iron core of the electromagnet of the telegraph instrument is surrounded by a copper sheath, consisting of a tube and washers. This damping circuit reduces the magnetism of the iron produced by the alternating current to such a small amount that it does not interfere with the action of the instrument. In the second method the telegraph instrument is shunted by a condenser; a small liquid condenser of three cells was found to be sufficient on the circuits tested. Full particulars of these experiments will, no doubt, be given when the report of the Swedish experiments is published.

The third effect is due to static induction between the charged trolley wire and the telegraph wire. A charge will be induced in the telegraph wire which is a function of the potential of the trolley wire and is independent of the current in it. As the potential of the trolley wire is alternating the induced potential will also be alternating in sign. The potentials induced in actual cases are surprisingly large. For the Hamburg-Altona line it is calculated that the difference of potential between the telegraph wires and earth would be 1,200 volts, while on the Swedish line the difference of potential is 4,500 volts. If the wire is earthed, the alternating current which will flow in and out of it will be very small—only a few hundredths of an ampere—owing to the small capacity of the line; but this would be sufficient to give a fatal shock. The use of the metallic return for the telegraph circuit does not eliminate this charge, but roughly doubles it by doubling the capacity of the circuit. The simplest way to avoid this is to earth the circuit at one point, or on long lines to earth it through high resistance at several points. These leakage paths will not interfere appreciably with the telegraph currents.

The same three effects are produced on a telephone circuit, but they cannot be dealt with in quite the same way. The induced E. M. F. is sufficient to cause a low "hum" in the receiver, which can only be eliminated by putting the wires in a cable. The static charge can be earthed through inductances which allow the low periodicity currents to pass, but not the high periodicity talking currents. All effects are eliminated by using underground cables for both telegraph and telephone circuits.

In calculating the sizes of trolley wire and feeders, etc., the effects of the self-induction of the circuit must be allowed for. If the power factor of the load is good, the self-induction of the line will cause very little drop of voltage at the far end; but if the power factor is low, for instance, on a section of line with only one train on it at the moment when that train is starting, then the induction of the line increases the drop considerably. The drop in voltage at the far end of the line is, of course, quite a different amount from the drop in the return circuit, which may be larger.

It is advisable to adopt a high voltage for the trolley wire; the advantages are many, and the disadvantages mostly imaginary. The higher the voltage the smaller the current, and the less are the effects of induction on neighboring circuits, and the less the drop in the rails and the better the regulation of voltage. The only undesirable effect which increases with the voltage is the static induction. By far the most satisfactory insulation for all high-tension circuits is porcelain, and with porcelain it is hardly more difficult to insulate for 20,000 volts than for 3,000. The most common objection raised to the higher voltage is the vague one of danger. The danger of falling tramway trolley wires is often spoken of, but it perhaps may not be generally known that there has never been a fatal accident in England due to a broken trolley wire. On careful examination it is difficult to see why 20,000 volts is more dangerous than 3,000; the lower voltage is quite sufficient to kill, and the higher can do no more. Whatever the voltage, it must be recognized that it is fatal to touch the trolley wire, just as it is recognized that it is fatal to stand in front of an approaching train. Nor does the higher voltage materially affect the reliability of the system. In ordinary continuous-current systems the power is all generated and distributed at high voltages, usually between 6,000 and 11,000 volts. Of course, these are reduced before reaching the motor, but so they are on the single-phase system. It will, however, be wise to proceed gradually in raising the voltage, in case any disadvantage should be found in practice which has not been foreseen. This course is being adopted on the Continent, and 20,000 volts has already been reached; this is quite a low figure compared with ordinary practice in transmission plants. Fortunately, the great flexibility of the single-phase system makes it perfectly easy to alter the voltage, and for the same rolling stock to run over lines with different voltages. By merely altering the grouping of the coils on the transformers in the carriages any trolley voltage can be used.

The Trolley.—Various forms of bow collector have been used, and for moderate speeds they are all satisfactory, but for high speeds special designs are necessary. The main object of the design must be to reduce the inertia of the moving parts, particularly of the actual contact bar. The Zossen experiments have shown how this may be accomplished by building the bow up of several parts connected by springs, thus making an extremely flexible construction, having very little inertia at the end, which is the only part which has to make very quick movements, while the lower and heavier parts follow more slowly and provide for the larger motions. The level of the trolley wire has usually to be lower when passing through bridges than in the open, and the bow must have a sufficient range of motion to allow for the extreme differences of level. It is also an advantage if the design will allow the bow to reverse itself when the car is run backward without forcing the trolley wire to rise. The bow is raised and lowered by air pressure; it is mounted on insulators on the car roof.

It would lead too far to attempt to describe the single-phase motor. It is sufficient to say that the motors which have so far been used for electric traction are mainly of two types—the compensated series motor and the compensated repulsion motor. Both have special advantages, but at present the series motor appears to be rather the better. It was at first supposed that the repulsion motor might be wound for high pressure, and thus save the transformation of the whole power in the car, only that part of the power required for excitation being transformed. It has,

* Paper read before section G of the British Association.

however, been found that the starting of the repulsion motor under these conditions is unsatisfactory, and in recent equipments main transformers have been used. These, however, do not do away with the second transformer for the magnetizing current, so that two transformers are generally required with this type of motor. Both motors have series characteristics, good power factors and fairly high efficiencies. The losses in the motors are, however, higher than in continuous-current motors, and forced ventilation is generally used to carry off the heat. Some writers have assumed that the motors must be made much bigger to enable them to get rid of their heat by simple surface radiation and conduction, as is usual with continuous-current motors. The simple expedient of artificial cooling is a better method of dealing with the problem.

It has been stated by several writers that the effective adhesion of the single-phase locomotive is less than that of the continuous-current locomotive, because of the pulsating nature of the torque given by the single-phase motor. This, however, is not the fact.

The speed of the motors is controlled by connecting them to different numbers of turns on the secondary of the transformer, thus varying the voltage on their terminals. The compensated repulsion motor has also its magnetizing current varied in the same way by connecting it to different numbers of turns on the secondary of the small transformer. No resistances are required, and there is, therefore, none of the loss which is inevitable with continuous-current motors. The speed of the motor when running can be regulated to any extent, which can only be done with continuous-current motors to a very limited extent by special devices. The actual switching is done by contactors, as in the continuous-current system. Single-phase magnets are very suitable for operating the contactors; they have the very advantageous property of taking current in proportion to the gap, so that as they close they automatically reduce their current; thus the magnets may be wound to give a large pull at a distance without overheating when kept in circuit. The troublesome vibration has been entirely got over by means of a small short-circuit ring round part of the armature. The great simplicity of the control enables the whole of the switching to be done with seven contactors, including the reversing switches. The rest of the motor car equipment is very similar to the usual continuous-current apparatus.

It is impossible to deal to-day with the generation of single-phase power. The introduction of single-phase traction is directing attention again to the subject, which has been rather neglected in recent years, owing to the greater popularity of two and three phase. The size of single-phase generators is rather larger for the same output than that of three-phase generators. Many different methods are being tried for regulating the voltage, and it seems likely that before long a good self-regulating single-phase generator will be available, though at present the regulation leaves a good deal to be desired. This is not a very important matter so far as the traction is concerned, but it introduces difficulties if the same circuits are used for lighting. This difficulty only arises when the load is very variable, as in small installations, and disappears when the load increases and gets less peaky.

I hope I have said enough to show how varied and numerous the possibilities of electric traction are, and that while many interesting problems are arising in connection with the new system of electrification, they are being successfully solved, and that there is no serious difficulty ahead.

It is very much to be hoped that English railway engineers will not lag behind their foreign confrères in introducing electricity on their lines. It is not to our credit that there should not be a single line equipped with single phase in this country when lines are already working in Italy, Austria, Germany, France, Belgium, America, and Sweden. It is not to be expected that railway companies will embark on extensive schemes at first; it is, therefore, all the more necessary that they should at once put in hand short lines, so that they may become acquainted with the merits and possibilities of the single-phase system.

INCANDESCENT LAMPS AND THE GRADING OF VOLTAGES.*

By Sir WILLIAM HENRY PREECE, K.C.B., F.R.S.

LIFE.—The life of a glow (incandescent electric) lamp is dependent entirely upon the voltage that maintains it alight. If a lamp be specified to give 16 candle-power with 110 volts at an efficiency of 3.5 watts per candle it may give this result at starting, but surely and certainly will give less and less light, however constant the voltage may be. It will deteriorate more rapidly if the voltage be variable, especially if it exceeds the standard 110-volt pressure. I mention particularly the 110-volt. The other standard pressure is 220 volts, but manufacturers have not yet introduced a 220 as good as the 110-volt lamp. The latter requires quite 20 per cent more energy for the same light than the former, and it would be decidedly economical to fix 110-volt lamps—two in series—on 220-volt circuits. I am doing this on my own installation in Wimbledon. In fact, it has been proved in America that the 110-volt lamp has three times the useful life of the American 220-volt lamp, and that 110-volt lamps at 3.1 watts per candle and 220-volt lamps of 3.8 watts per candle have equally useful lives. The former will absorb 30.4, the latter 24.6 units (kilowatt-hours), the difference being 5.8. If we take the mean price per unit at 3½d. (7 cents), it indicates that the 220-volt lamp costs 10d. more every 500 hours than does the 110-volt lamp, which is more than the cost of the lamp. The reason for the difference between the two lamps is the impossibility of "flashing" the fine filament of the 220-volt lamp. The consequence is that the lamps have to be worked at a lower temperature.

Lamps may last alight for many hundred hours. I have known lamps that have endured through 6,000 hours, but it is quite certain and easily proved that after a lamp has dropped from 16 candle-power to 12.8 candle-power it is wiser and cheaper to remove and replace it with a new lamp. The useful life of a glow lamp is defined as the time taken for the mean horizontal candle-power to drop 20 per cent from the standard value.

Blackening.—This loss of light is due as much to the blackening of the bulb as to the increase of the resistance of the lamp. The blackening is so regular in its growth through age, when the voltage is maintained constant, that Dr. Clayton Sharp proposes to classify used lamps by comparison with a scale of standard lamps artificially aged. This simplifies the assortment of played-out lamps immensely. It is quite easy to determine the point when the lamp has reached the end of its useful life. Indeed, the bulb blackening gives directly the percentage of its useful life. It is a test independent of candle-power and of efficiency and very quick. The lamp tells its own story.

The useful life of a lamp, as already mentioned, is defined as the number of hours it takes for the candle-power to fall 20 per cent from its standard intensity. The absolute life is the period in hours it takes to expire by rupture of the filament. These hours may be continuous or intermittent. My experiments of 1894-95 showed that interruptions in lighting made no difference if the voltage remained constant. Messrs. Ayrton and Perry proved that it made no difference whether the currents were continuous or alternating, but subsequent experience has shown that on both systems variation of voltage has a deleterious influence.

Standards.—The following candle-powers are recognized as standards: 8, 16, 32. It is proposed to add to them 12 candle-power and 25 candle-power. The continental standards are 10, 20, 30 candle-power.

It is impossible to tell how few lamps comply with specified standards unless they are tested on purchase and tested periodically during life. It is impractical to expect that any users other than the very large ones would undertake this duty. Hence, if testing is to be done effectually it must be done by the authorized distributors.

Voltage Variation.—The most serious disturbance in our systems of distribution of electrical energy and a prolific source of decay and destruction of our glow lamps is the variation of voltage, not only from our specified standard pressures, but in any one system, from the individual pressure adopted in the network of that system. This latter variation is an evil, not only in the feeders, but in the service lines, and frequently in the internal circuits of lamp installations. No serious attempt has yet been made to secure uniform pressure throughout the network of distribution systems by introducing voltage regulators.

The departure from the standard pressures of 110 volts and 220 volts adopted by the Engineering Standards Committee is shown by the following table:

Voltage of circuit.	Lighting in kilowatts.	Number of generating stations.
100	72,701	54
102	463	1
103	160	1
104	2,824	1
105	7,208	6
107	3,567	1
110	7,523	11
115	5,103	3
120	120	1
150	2,379	3
200	129,690	81
204	16,603	2
205	3,112	1
210	21,361	26
214	3,568	1
215	479	1
220	66,935	82
225	144	6
230	104,720	122
235	88	1
240	45,389	57
250	18,249	10
	512,486	472

In 472 systems only eleven adopt 110 and eighty-two 220 volts, while 122 employ 230. Most of these, however, were established before the standards committee was formed, but many have been established since. The whole object of a standardized system of pressures is to secure uniformity of lamps and a reduction of the very numerous processes in factories, so as to reduce their prime cost. Standardization thoroughly carried out means economy, cheaper manufacture to the maker, lower price to the user.

There is a great deal too much technical individualism about, and the time has come for the Incorporated Municipal Electrical Association and the chairmen of electric-light companies to take some steps to secure uniformity of practice. This is necessary for the benefit of the public, for greater uniformity tends to greater economy. The ruling force is £, s., d., and not mere fad. The great and rapid growth of the power demand adduces an additional reason why standardization should be enforced. It is of even more consequence with motors than with lamps.

The variation of pressure in the network of a system is therefore a serious evil, for it affects not only the life but the efficiency and candle-power of the lamps, and especially of the high-efficiency lamps which we hope standardization will secure in the future. Mr. Wilkinson, of Harrogate, says: "Many lighting circuits are unfit to supply any lamps of higher efficiency than 'traction' lamps, while numbers of supply networks are badly laid out and so stinted of copper that it is necessary to maintain abnormal pressure at the feeding centers during heavy loads in order to produce a satisfactory light in the remote districts." (Inst. of E. E., February, 1906.)

Voltage Regulation.—Voltage regulation makes for increased and greater uniformity of light. There are several excellent systems of voltage regulators which automatically maintain the pressure constant to within a small percentage for both continuous and alternating systems, but the main difficulty is in the original design of the network when fear of financial failure demanded low estimates of cost to secure the support of timid councils.

Batteries are most effective regulators for continuous-current systems, especially at sub-stations, but a good, practical method is to regulate the current in the field-exciter circuits of large dynamos, while small dynamos, if not compounded, are regulated by resistance thrown in or out by relays.

Alternating-current systems are also regulated by varying exciter current and by varying the induction ratio of static transformers.

Grading Voltages.—One of the most serious evils brought out by the inquiries of the standardization committee has been the very faulty rating of the lamps by the majority of the British makers. I know of a case where a householder could not get his servants to use eight-candle lamps because they gave "so poor a light." He got the manufacturer to mark them as 16-candle lamps and all grumbling ceased, though the light remained the same. A large number of 220-volt and 110-volt 16-candle-power lamps were purchased in the open British market and sent over to New York to be compared with the American-made lamp. They were tested. Their performance was extremely wretched. They agreed neither with their marked voltage candle-power nor efficiency. They showed a miserable absence of uniformity. They averaged out 13.2 candle-power and 4.51 watts per candle. The American lamps averaged 16.2 candles and 3.83 watts per candle with great uniformity.

Both sets of lamps were subjected to the American rapid-life test. They were set up at 3.1 watts per candle. The English lamps averaged a life of 82 hours, the American 156 hours—a superiority near twice as good!

But this result was also obtained—that the American 220-volt lamp has five times the useful life of the English-made lamp of similar voltage!

This experiment was repeated at home. Lamps were purchased in the open market in London and sent to the National Physical Laboratory. The results confirm in many respects the American figures.

The standard adopted in this country for pressures allows a variation of 10 per cent on either side. This means a wide margin of from 99 to 121 volts in the one class and from 208 to 242 volts in the other. Hence lamps may be made and supplied of any voltage within these wide limits. Since the pressures are so ill selected and manufacturers can find a market for virtually all that they make, owing to the callousness of users, no care is taken to select and stock lamps in their various grades, or to make them of uniform structure. Moreover, the absence of specification and of tests has encouraged great looseness of practice in the users who buy as well as in the tradesmen who sell. The result has been faulty rating, poor efficiency, nasty lamps, and great waste. The rejected cheap lamps of the Continent have been dumped down in this country and their marking neglected. Experience shows that the cheap lamp proves to be a swallower of energy, and a costly agent. I have heard of a case where Continental-made lamps absorbed 9.14 watts per candle. The user gives attention to his quarterly bill only, and when he finds his bill increasing per lamp, as it invariably does with time, he does not attribute it, as he should, to the inefficiency, gradual and natural deterioration of the lamp with use, the diminution of light and the waste of energy, but to the wiles of the authorized distributor. He often blames the system and returns to gas. The persistent use of an inefficient lamp is senseless and extravagant. Many a user is paying for twice as much energy as he needs. No wonder that the gas interest rejoices. There is distinct room for the expert illuminating engineer who can test pressure candle-power differences *in situ* and who can advise the user on novelties and economies.

The chief remedy is to make the correct rating of lamps imperative. Specification and testing will be beneficial and will tend to secure more care in selection and better efficiency. Greater regulation of pressure would facilitate the grading of lamps into groups and enforce the similar grading of our networks into zones of pressure. But falsification of brands must be made illegal. Lamps should be grouped in classes to meet this point somewhat in the following way:

110-volt lamps...	100	105	110	115	120
220-volt lamps...	200	210	220	230	240

No others should be sold, and authorized distributors

* Part of a paper read before the British Association (Section G) at York, England, August 6, 1906. It is especially interesting as showing British practice and its variation from American practice.

should restrict their systems and regulate their pressures so as to maintain pressure constant in each district. There is no fear of disturbing the price. In fact, manufacturers assure me that such a grading would so improve their own output of lamps and reduce their cost of manufacture that with a good specification they would be able not only to supply better lamps, but cheaper ones. This is found to be the case in America, where voltages are graded to suit the output of the makers, and users find their lamps much more uniform in performance.

Tests.—Testing is thus the climax of all that has been said, and it is the only means that we possess to secure efficiency and prevent fraud. Moreover, it gives the right to any public body to possess a trademark under the Trades Mark Act and to prosecute infringements as ordinary cases of fraud. With great care, much consideration and a mass of evidence and experience the Engineering Standards Committee has prepared but has not finally settled a specification which will run the risk of becoming a dead letter unless some arrangements are made for branding the lamps purporting to be to standard specification. Local authorities are already inspectors of weights and measures, and they can all become so for electric lamps if they establish a testing laboratory—a by no means expensive undertaking.

If the actual standards are left in the care and under the control of the National Physical Laboratory they will be reliable, and manufacturers and consumers will have confidence in their readings. If, moreover, the local inspectors maintain their secondary standards in good order by periodical examinations and renewed certificates they will be equally satisfactory, but it must be clearly understood that pentane standard lamps and secondary glow lamps can only retain confidence if they are controlled and calibrated in properly equipped laboratories under the management of statutory authorities. Consumers cannot do their own testing effectively, legally. The duty must be relegated to a properly legalized testing institution. Nothing can surpass the engineering of our central stations in England, for the quality and design of our plant remains a pattern to the world, but nothing can equal our internal commercial management and the financial conduct of the business, for as a rule management and control are lamentably wanting. The lamp—the aim of the capital sunk—is outside their business, and the light for which payment is made is beyond their jurisdiction. Lamps must be renewed at proper intervals. It is barbaric to let them break. Lamp control is almost universal in the United States.

The gas people in the United Kingdom are wiser. They are now undertaking the supervision and maintenance of mantles for a small annual charge. It is done in York for 3d. per burner per month; in Ipswich for 3d. per burner per quarter.

It is somewhat humiliating and certainly should excite earnest thought that nearly all the recent advances in developing the electric and gas light in this country have emanated from Germany or America. The Nernst lamp, the Welsbach mantle, tantalum, osmium, zircon glow lamps, flaming arcs, etc., are all importations. Is the Lion asleep? Are we wasting our energies in religious discussion? Is the spirit of enterprise abroad? Is our abundant money poured into less profitable undertakings? Are we checked by grandmotherly legislation? Something is wrong somewhere. The one thing I wish this paper to expose is the shocking technical ignorance of the ordinary householder, the absence of any legal power to protect the user in the quality of his electrical apparatus purchased on the open market, and the apparent growing decay of honor among our manufacturers. "Made in England" is becoming a reproach to us.

SOME NOTES ON EARLY DYNAMOS.

EARLY dynamos were of small power, and ran at high speeds in order to give the required voltage. A report of Trinity House, in 1877, gives particulars of seven machines tested at the South Foreland Lighthouse by Prof. Tyndall and Sir James Douglass. The following table gives the data of them:

	Weight.	H.P.	R.P.M.	Cost.
Holmes	5,747	3.2	400	$2,750
Alliance	4,081	3.6	400	2,275
Gramme (No. 1)	2,856	5.3	420	1,600
Gramme (No. 2)	2,856	5.75	420	1,600
Siemens (large)	1,306	9.8	480	1,325
" (small)	420	3.5	850	500
" "	420	3.3	850	500

It may be of interest to add a few data of subsequent years:

Messrs. Siemens Bros., 1882.

No.	H.P.	R.P.M.	Price.
D_5	1½	1,200	$225
D_3	2½	950	325
D_2	4	600	475
D_1	7	550	1,100
D_0	15	500	1,450
D_{00}	20	400	1,800

The Gülcher Company, 1883.

No.	H.P.	R.P.M.	Price.
1	2½	1,500	$400
2	4½	1,300	500
3	7½	1,100	800
4	13½	900	1,250
5	25	700	2,250
6	50	550	4,000

Messrs. Paterson and Cooper, 1882.

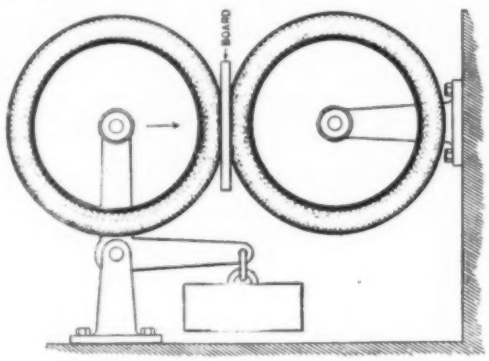
No.	K.W. output.	R.P.M.	Price.
1	0.96	1,800	$180
2	1.9	1,700	270
3	4.0	1,600	400
4	6.4	1,500	600
5	12	1,200	900
6	20	1,050	1,250
7	32	900	2,000

Such high speeds as those indicated above could not be met except by belt driving.

THE SCIENTIFIC INVESTIGATION OF AUTOMOBILE PNEUMATIC TIRES.

By the English Correspondent of SCIENTIFIC AMERICAN.

ALTHOUGH it is recognized that the most supreme tests that can be imposed upon an automobile pneumatic tire are those on the highroads, when running under normal conditions, yet testing operations carried out upon this basis are accompanied with serious disadvantages, the greatest of which is the limit in range of action, and the extent of the time required to carry out the investigations, while exceptionally severe tests are impossible, owing to the risk to human life. In view of these considerations, an interesting laboratory testing and experimental plant has been installed by the manufacturers of an English tire, which possesses several interesting and novel features.



APPARATUS FOR TESTING TIRES UNDER COMPRESSION.

This apparatus is not intended to act as a substitute for the more conclusive running road tests, but serves as an excellent and more convenient substitute, since thereby it is possible to determine approximately the most suitable of a series of varying systems of construction.

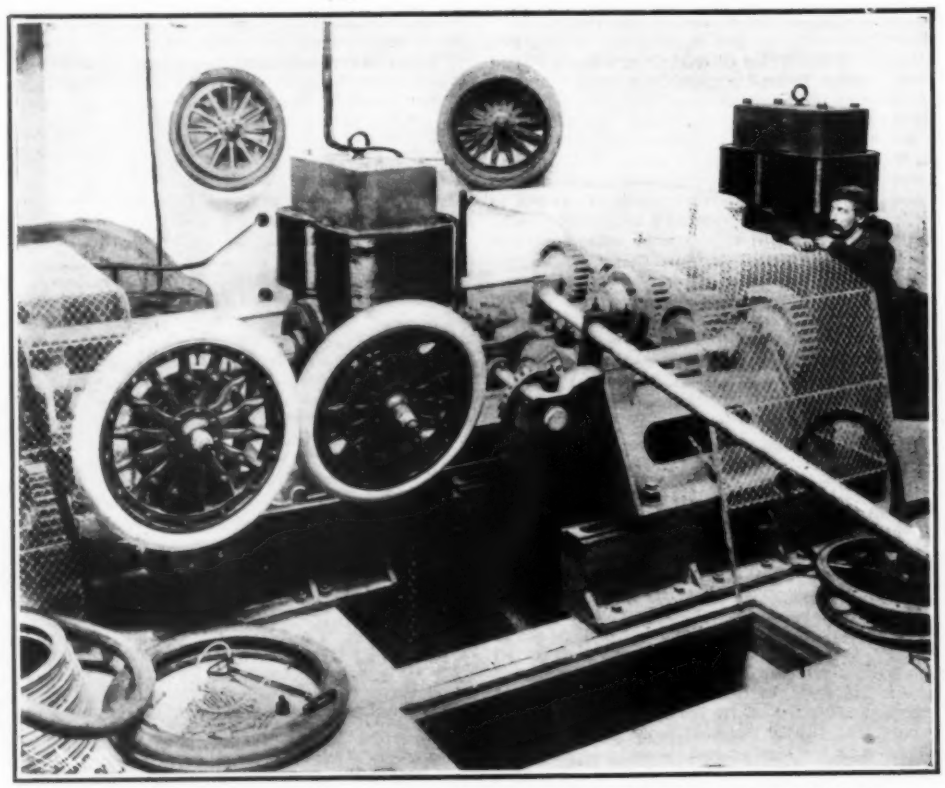
The most interesting section of the laboratory equipment is the apparatus employed for investigating the behavior of the tire under conditions as approximate as possible to those obtaining on the actual road. In order to obtain the correct flattening of the fabric of the tire at the tread, where it is naturally distorted under load, two pneumatic-tired wheels are run together in contact in the manner shown in the accompanying illustration. Both tires are inflated to the same pressure, so that each tire constitutes the equivalent to a flat road for the other.

The one wheel is pressed against the other wheel by a lever carrying heavy weights, which are suspended in the pit below the machine and which represent the load. The second wheel is so arranged that it may be turned upon a horizontal line at right angles to its axle. When so turned it is made to revolve in a different plane from the first wheel. The support of the second wheel, in order to keep it steady, is attached to a heavy pendulum weighing upward of 4,480 pounds carried in the pit below the machine. When this pendulum is caused to oscillate to and fro while the wheels are revolving, the strains which are thus set up in the fabric of the tire are similar in character to those which are imposed when an automobile is driven rapidly round curves varying in direction.

Two electric motors, each of 50 brake horse-power, are utilized in the operations, one employed as a motor and the other as a dynamo brake. If the first wheel is driven by the No. 1 motor and the second motor is disconnected, the machine is then "running light;" and if the pendulum is stationary in a vertical position the conditions of running are then closely similar to those of tires on a loaded car running on a level road, the first wheel being the driving, and the second wheel the front wheel. If the second motor is used as a brake dynamo, then the conditions at the first wheel resemble a loaded car climbing a very steep hill, while the conditions at the second wheel are similar to those of a loaded car running down a very steep hill with the brakes fully applied.

A special apparatus is mounted on the electrical switchboard, by means of which the investigator can ascertain at a glance the electrical horse-power supplied to the motor, and also how much is given out by the brake. By making allowance for friction of the machine, an approximate estimate may then be obtained of the power absorbed by the tires, which is of great utility in comparing the various types of manufacture.

There is no limit to the nature of the tests which may be carried out with this apparatus. It can be run at a wide range of varying speeds. The strains it is possible to impose upon the fabric of the tire are far greater than could possibly be applied on the road, with the accompanying advantage that no risk is inflicted upon life or limb. The power of a tire to resist the tearing of the cover from the rim when running at a high speed, and with the pendulum in action, affords every assumption that the tire will not fly from the rim of the wheel when in actual use. The records which have been obtained from the experiments with this appliance are far more valuable than the results of tests carried out upon the highroad, for the simple reason that the conditions are exactly uniform, whereas all road investigations are influenced to a very great degree by the condition of the road, weather, and to a certain extent by the driving capabilities and skill of the driver.



TESTING MACHINE FOR INVESTIGATING THE BEHAVIOR OF PNEUMATIC TIRES UNDER RUNNING CONDITIONS.

The lesson taught generally by the foremost enterprises of the day, in their respective industries, is that their success has been largely due to the efficiency of their working forces. Thus in recent years the importance of possessing a high-grade organization has impressed itself more and more upon the mind of the business manager so that at the present time this possession is considered, by those who are most competent to judge, by far the most valuable of all commercial assets.

LIGHT-WEIGHT GASOLINE MOTORS FOR AERONAUTICAL WORK.

By Our PARIS CORRESPONDENT.

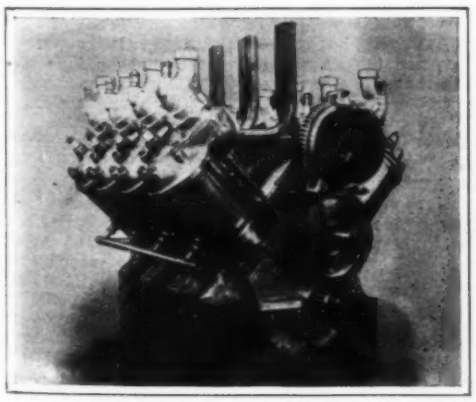
THAT French motor constructors are making great progress in building specially light and powerful gasoline engines for aeronautic work is shown in the new Levavasseur motor, which is illustrated herewith. M.

LIGHT-WEIGHT, FLAT-TUBE RADIATOR FOR AERONAUTICAL MOTORS.

Levavasseur has been engaged for a number of years upon the problem of a light motor, and it is only recently that he brought out his new eight-cylinder engines, which have had such a great success in France and elsewhere. He can now build a motor from 20 horse-power upward which weighs not more than 3.4 pounds per horse-power. Santos Dumont made use of two of these motors in experimenting with his aeroplane. At first he used a 24-horse-power type, but after M. Levavasseur succeeded in building a 50-horse-power type, Santos Dumont adopted this instead, as he found that he needed more power. With this engine he has succeeded in attaining a speed of about 25 miles an hour and in flying over an eighth of a mile with his aeroplane. Other aeronauts have adopted the "Antoinette" motor, as it is called, including Capt. Ferber and M. Bleriot, for their aeroplanes; Count A. da Schio, for his airship "Itala"; the Prince of Monaco, who is mounting a motor of this type on the helicopter which M. Leger is constructing.

M. Levavasseur has furnished the following description of his new motors:

The first desideratum of a gasoline motor is to secure steady running, with but little vibration. This can be accomplished, first, if the center of gravity of the moving parts r mains fixed; second, if the couple is constant. The first condition is easy to realize, but for the second a certain number of cylinders is needed. With four cylinders the couple is alternately positive and negative, and a heavy flywheel is necessary. Using double the number of cylinders, or eight, the couple is always positive and nearly constant. The flywheel can now be suppressed, for the pieces in movement will suffice in themselves. Besides these advantages, the eight-cylinder motor has another one which is valuable, namely, that owing to the continuity of its couple, the motor can be run in either direction by using a device placed upon the cam-shaft. The maneuver is carried out by simply drawing out a button placed at the end of this shaft, which shifts the cams. With the above disposition, the "Antoinette" eight-cylinder motor has almost the same qualities as a double-cylinder, double-acting steam engine whose direction of rotation is regulated by the valves. Moreover, the motor will start by simply switching on the ignition current. The ignition is carried out by means of a single vibrating spark-coil, which is designed to give eight sparks per second, combined with a secondary distributor which sends current to each spark plug of the eight cylinders in turn. A small self-excited alternator working at high frequency and driven by the motor itself, can be used, and it is started by a handle at first. These two systems of



END VIEW OF 25-HORSE-POWER 8-CYLINDER MOTOR, SHOWING HIGH-TENSION DISTRIBUTOR ON TOP.

igniting, which, during the required time, produce a continuous spark at the plug, allow of varying the ignition period with great precision. During the time in which the distributor remains in contact with the same spark-plug as many as ten sparks are produced.

The carburetion is worked by an improved method. It consists in the use of a small gasoline pump connected by a fine tube with the gasoline tank and operated by the motor. Gasoline is taken by the pump and sent into eight small distributors placed each upon the cap at the top of the cylinder. These distributors are designed to regulate the quantity of liquid which is needed for each cylinder and to hold it until the period of the inlet, at which time it is released and the inrushing air draws it into the cylinder, spraying it at the same time. Means are provided for regulating the output of the pump by changing the stroke of its piston by hand while at the same time keeping the general automatic action due to its connection with the motor. In this way, regardless of the composition of the air and its temperature, the best mixture is obtained, and its economical operation is secured. As each cylinder has, so to speak, its own carbureter, no special carbureter is used with the motor. This suppresses the use of the large supply tubes going from the carbureter to the eight cylinders. The gasoline feed tubes which replace them are of very small diameter.

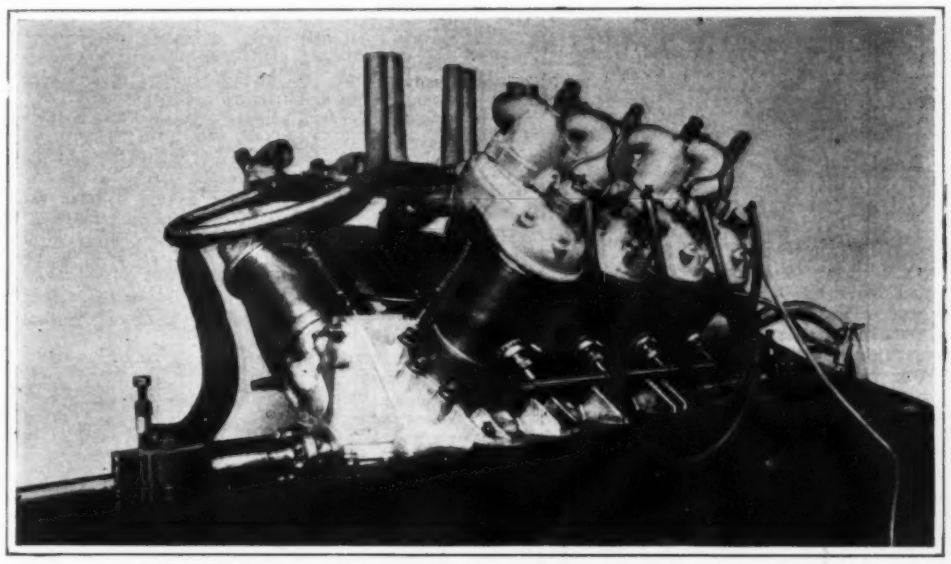
As will be observed in the engravings, the 50-horse-power and the 24-horse-power motors have about the same general build. The upper part of the crank-case has two faces inclined at 45 degrees, and four cylinders are fixed to each face. A common crankshaft receives the rods of all the pistons. This shaft is carefully worked and is hollow wherever possible in order to give lightness. The two piston-rods of each opposed pair of cylinders are made to work upon a common crank. Above the main shaft is a cam shaft which is driven by gearing placed outside the case. The latter shaft works the eight cams of the exhaust, while the inlet is generally automatic, although if need be it can be worked from the same cam shaft. Special plates are fitted around the bottom of each cylinder between them so that they can be bolted down more securely to the crank case. In this way the cylinder proper is left free, and it is turned on the lathe inside and out. Its rounding head has a hole in it for the spark plug. The crank case is braced inside by a series of webs, and the crank shaft is carried in five bearings. Around the cylinder is fitted a light brass tube which serves for the water jacket. The outer cylinder head in aluminium clamps this jacket against a flange on the outside of the cylinder near its base. At the side of this head, contained in a steel cylindrical lining, are the two valves, which are of nickel steel. Above the valves, in each aluminium casting, is the atomizing device which receives the copper gasoline tube, and at the side a large opening admits the air. In the aluminium cylinder head the water circulates, and owing to the good heat conductivity of this metal, the valves and their seats are well cooled.

The explosion of the gas is produced in the upper part of the cast-iron cylinder, which has an integral cylinder head. It is to be noted that the brass water jacket tube is fitted into the aluminium casting at the top, and in all cases is given a clamped joint, without brazing. The pieces of the motor which undergo alternate strains, such as the crank-shaft, wrist-pins, cranks, cylinder brace-pieces, are of high quality steel and very light and solid, being capable of withstanding pressures of 14,000 pounds per square inch. The entire cylinder, having a diameter of 5.118 inches, the aluminium head, the copper water jacket, the seats and the valves weigh complete about 13 pounds, and yet the cast iron will stand strains of over 2,000 pounds per square inch, as will also the aluminium and bronze entering into the construction of the motor.

On account of the large amount of machine work on these motors, the price is high, ranging from $2,000 upward at the present time. One of the views shows the extra-light radiator which has been designed by M. Levavasseur for use upon airships or aeroplanes. It is built up of a set of flat copper tubes about 1½ inches wide, with air spaces between, so as to give a good cooling. The surface is about 3.60 square yards.

For the 20-24-horse-power motor the bore and stroke are each 3.2 inches, and the weight 80.6 pounds. The speed is 1,800 revolutions per minute. The 50-horse-power motor has a 4.333-inch bore and stroke and weighs 154.32 pounds, not including the reversing mechanism. Including the latter, with gasoline, pump, piping, wires, plugs and spark coil, it weighs 187.39 pounds. The speed at which it develops its power is 1,400 revolutions per minute. This motor occupies a space 29.13 inches long by 23.62 inches wide and high.

The "Antoinette" motor has been very successfully applied to launches, and in this case the main shaft operates the propeller directly, without a friction clutch or reverse. As it always has two cylinders in action, it starts up when the ignition current is switched on. In the last Motor Boat number of the SCIENTIFIC AMERICAN we had occasion to show a launch fitted with this motor. Others have been built, and have won many records. Last year the "Antoinette III," using two 80-horse-power motors coupled in tandem, won the 100-kilometer record at Evian, on Lake Leman. On Lago Maggiore it won the Duke of Abruzzi Cup. Its finest performance was on the Lake de Garde, where it made a 90-mile run at a speed of 30 miles an hour. A later boat, the "Antoinette IV.," made a good run of 120 miles in the bay at Monaco during this year's event. It was purchased by a German sportsman, Herr Braunbech, and won the Emperor's Cup at the Kiel regattas. M. Levavasseur is now engaged in building a 130-horse-power motor which will have sixteen cylinders, and is to weigh but 220 pounds. This motor is now in construction at the Paris shops.



THE 50-HORSE-POWER, 8-CYLINDER LEVAVASSEUR MOTOR WITH WHICH SANTOS DUMONT WAS ABLE TO MAKE A ⅛ MILE FLIGHT IN HIS NEW AEROPLANE.

The cylinders have clamped brass water jackets held in place by false aluminium heads. A curved elbow leads to each automatic inlet valve, to which also the gasoline is pumped through a fine pipe and atomizer nozzle. The curved exhaust pipes project upward between the cylinders. The weight of the motor complete is 187.39 pounds.

AN EXPERIENCE IN OILING A CITY STREET.*

By FRANK H. WRIGHT.

THE writer does not care to pose as an expert on the use of oil for road purposes, for he is none such, but being anxious to contribute something to the success of the Birmingham meeting, he has assembled a few facts gained from an experience of his own during the past summer.

The street had had some work done on part of it the preceding spring. There were two blocks, about 700 feet in all, the upper block having good crown on about a six per cent grade, and the lower block a much flatter crown, dropping off from the upper block on about an eight per cent grade to about one-half way down, then about a four per cent. There was a total rise of about forty feet in the two blocks, and in heavy rain storms there had always been very much washing of the gutters and in the wagon tracks on the crown, as the soil was a very soluble yellow clay, Helena being the termination of Crowley's Ridge, which is well known to engineers and geologists of the Mississippi Valley.

The street was thoroughly plowed twice for a width of forty feet, the amount used for traffic, the plow being a small pointed Avery with a steel beam. After plowing, a disk harrow was thoroughly applied, after which a toothed harrow was used until the whole street was like ashes. One team only was used on this preliminary work with a driver, but a shaker was used with the plow. The plowing and harrowing consumed about two days' time.

To get the oil from the car a small lever pump was bolted to the floor timber of the car at the side of the tank, and a connection was made to the inside of the tank by siphon through the dome of the tank, made of two-inch wrought iron pipe with the necessary fittings. The driver with one man to pump was able to leave the street, go to the car and fill his three 52-gallon barrels and return in exactly thirty minutes.

A strip was taken on one side of the street about fifteen feet wide, the street not being closed to traffic, and three men, each armed with a large two-gallon garden sprinkling can, with spray removed, poured the

* Municipal Engineering.

oil on the pulverized surface, each man working in his own section, about twenty feet long, the driver filling the sprinklers by pumping from the barrels with a tin oil pump. The writer inaugurated this system of distributing oil during the mosquito campaign of the previous year (1905) and found it very satisfactory.

A load of coarse sand was dropped about every fifty feet on the oiled strip, and during the absence of the wagon in refilling the barrels this sand was spread by the men in the same manner that sand is applied over a newly grouted brick pavement in thin layers.

After one side was oiled and sanded, a strip on the other side was treated likewise, and the center strip was again plowed and harrowed, having become compacted by traffic, and also treated, after which the whole street was run over with a toothed harrow, and was then gone over and oiled and sanded a second time, but was not harrowed. The street was then thrown open to traffic.

This was all done the first week in July and until recently there has been comparatively little dust and no mud, nor has there been any more washing where formerly it was excessive after a hard rain, and we have had several hard rains this summer, one quite soon after the street was treated. I am of the opinion that the oil should have been renewed within sixty days.

We were, I think, fortunate in having rather hot weather in which to apply the oil. The gutters have still a good percentage of the oil retained, and the sod was enabled to make a good set, which of course reduces the wash. Time was taken in unloading one wagon (three 52-gallon barrels) and it took three men exactly one hour to dispose of the load over a surface of 15 x 100 feet, or 1,500 square feet. One man scattered with a shovel one wagon load (about 24 cubic feet) of sand over an area of 50 x 60 feet, or 3,000 square feet in fifteen minutes.

The oil was charged at $1.59 per 44-gallon barrel.

Team, 7 days at $3.00	$21.00
Labor, 11 days at $1.25	13.75
Foreman, 3½ days at $1.50	5.25
Total, labor account	$40.00
Oil, 47.14 barrels at $1.59	74.95
Sand, 35 loads at 75c	26.25
Total materials	101.20
Total, all items	$141.20

[Concluded from SUPPLEMENT No. 1611, page 25815.]

SOURCES OF INDUSTRIAL ALCOHOL.—II.*

By DR. H. W. WILEY.

AVERAGE composition: Frazier, of the Cornell station, has collected analyses of a large number of different varieties of potatoes and finds them to have the following average composition:

	Per cent.
Water	75.00
Starch	19.87
Sugars and dextrin	.77
Fat	.08
Cellulose	.33
Ash	1.00

According to Maercker, the sugar content, including all forms of sugar, varies greatly. Perfectly ripe potatoes contain generally no sugar or only a fractional per cent. When potatoes are stored under unfavorable conditions, large quantities of sugar may be developed, amounting to as high as 5 per cent altogether. In general, it may be stated that the content of sugar of all kinds will vary from 0.4 per cent to 3.4 per cent, according to conditions.

Experience in Germany has shown not only that liberal fertilization with nitrogen is favorable to the production of a large crop of potatoes, but also that this is accomplished without decreasing the percentage of starch therein.

It is evident from results of experiments that the liberal applications of nitrogenous fertilizers increases the yield per acre of tubers and of starch to a very marked extent, although the average percentage of starch present is increased very little.

Of all the common root crops, the potatoes, including the yam and the sweet potato, are the most valuable for the production of alcohol, meaning by this term that they contain more fermentable matter for 100 pounds than other root crops.

While it is seen that sugar beets, carrots, and parsnips contain relatively large amounts of fermentable matter, these roots could not compete with potatoes even if they could all be produced at the same price per 100 pounds.

A general review of all the data indicates that under the most favorable circumstances and with potatoes which have been bred especially for the purpose an average content of fermentable matter of about 20 per cent may be reasonably expected. It is thus seen that approximately 10 pounds of industrial alcohol can be made from 100 pounds of potatoes. If 60 pounds be taken as the average weight of a bushel of potatoes, there are found therein 12 pounds of fermentable matter, from which 6 pounds of industrial alcohol can be produced, or six-sevenths of a gallon. It has also been shown that at the prices quoted in 1905 the amount of Indian corn necessary for the production of a gallon of industrial alcohol costs not less than 15 cents. From this it is evident that the potatoes for alcohol making will have to be produced at a cost of not to exceed 15 cents per bushel, before they can compete with Indian corn for the manufacture of industrial alcohol.

Rice.—Composition.—Rice is not used to any great extent in this country for making alcohol, but it is extensively used for this purpose in Japan and some other countries, and has the largest percentage of fermentable matter of all the cereals.

The percentage of fermentable matter in rice is nearly 78 per cent. A bushel of rice weighs, unhulled, 45 pounds, hulled 56 pounds, and it therefore has about 34 and 43 pounds, respectively, of fermentable matter for the unhulled and the hulled rice. It is not probable that rice will ever be used to any extent in this country as a source of industrial alcohol, although it is used to a large extent in the manufacture of beverages, as for instance in beers, which are often made partly of rice.

Yield.—The area devoted to rice in the United States for the year 1905 was 482,479 acres, yielding 28.2 bushels per acre, or a total of 13,606,989 bushels, valued at the farm at 95.2 cents a bushel, or a total value of $12,955,748. The largest rice-producing area is in Louisiana, in which there were 240,037 acres devoted to rice, yielding 25.8 bushels per acre, or a total production of 6,192,955 bushels, valued at 89 cents a bushel, or $5,511,730. Texas, with a smaller acreage, namely, 214,490 acres, produces a yield of 31 bushels per acre, amounting to 6,649,190 bushels, worth $1 per bushel, having a total value of $6,649,190, a greater value than that of the crop in Louisiana. The other Southern States which produce rice yield only small quantities, the largest yield, besides those mentioned, being in South Carolina, in which 18,114 acres were reported as devoted to rice culture.

Rye.—Composition.—Large quantities of alcohol, chiefly in the form of alcoholic beverages, are manufactured from rye. It is, in connection with Indian corn, the principal source of the whiskies made in the United States. Rye, however, is not used to any extent in this or other countries for making industrial alcohol. Rye contains almost as much fermentable matter as Indian corn. A bushel of rye weighs 56 pounds. Wheat and other cereals, not mentioned above, are not used in this country to any appreciable extent in the manufacture of alcohol.

Yield—The total acreage devoted to rye in the United States for the year 1905 was 1,730,159. The average yield per acre is given as 16.5 bushels, and the total production 28,485,952 bushels, valued at the farm at 61.1 cents per bushel and having a total value of $17,414,138. The largest rye-producing State is Pennsylvania, in which there were 346,265 acres devoted to this cereal, with an average yield of 17 bushels per acre, and a total yield of 5,886,505 bushels, valued at 65 cents a bushel, with a total value of $3,826,228. Other large rye-producing States in the order mentioned are Wisconsin, Nebraska, New York, and Michigan. A number of the Southern States make no returns for rye whatever.

Spelt.—This grain, which is botanically a variety of wheat, more closely resembles barley, and, though not yet grown to any great extent in this country, there is a tendency, especially in the West, to increase its cultivation for stock feeding, due chiefly to its prolific growth. Under favorable conditions as high as 73 bushels per acre have been reported by the North Dakota station, and the analyses given show 70 per cent of fermentable carbohydrates. The weight per bushel is about the same as that of oats. It would appear that this crop might be worthy of consideration as a profitable source of industrial alcohol.

Sugar Beets.—The sugar beet is often used directly as a source of alcohol. Working on a practical scale in France, it has been found that from 10,430 tons of beets there were produced 183,624 gallons of crude alcohol of 100 deg. strength. The beets contain 11.33 per cent of sugar. From 220 pounds of sugar 15.64 gallons of alcohol were produced. The weight of pure alcohol obtained is a little less than one-half the weight of the dry fermentable matter calculated as sugar subjected to fermentation. About 18 gallons of alcohol are produced for each ton of sugar beets employed.

Sweet Potatoes.—Yield and Composition.—The sweet potato has not been used in the United States for the making of alcohol. In the Azores great quantities of sweet potatoes are grown for this purpose, and make an alcohol of fine quality, which is used to a large extent in fortifying port wines. There are large areas in the United States, especially in the Southern States, where the sweet potato can be grown in great abundance. The experiments at the South Carolina station show that as high as 11,000 pounds of sweet potatoes can be grown per acre. The percentage of starch is markedly greater than in the white or Irish potato. In all cases over 20 per cent of starch was obtained in the South Carolina sweet potatoes, and in one instance over 24 per cent. As high as 2,600 pounds of starch were produced per acre.

In addition to starch, the sweet potato contains notable quantities of sugar, sometimes as high as 6 per cent being present, so that the total fermentable matter in the sweet potato may be reckoned at the minimum at 25 per cent. A bushel of sweet potatoes weighs 55 pounds, and one-quarter of this is fermentable matter, or nearly 14 pounds. This would yield, approximately, 7 pounds, or a little over 1 gallon of 95 per cent alcohol. It may be fairly stated, therefore, in a general way, that a bushel of sweet potatoes will yield 1 gallon of industrial alcohol. The average yield of sweet potatoes, of course, is very much less than that given in the South Carolina reports, where heavy fertilization was practised. On plots to which no fertilizer was added the yield was about 8,000 pounds of sweet potatoes per acre, yielding in round numbers 1,900 pounds of starch. The quantity of sugar in the 8,000 pounds is about 350 pounds, which, added to the starch, makes 2,250 pounds of fermentable matter per acre. This will yield 1,125 pounds of industrial alcohol of 95 per cent strength, or approximately 160 gallons per acre.

The yield of sweet potatoes in the above computation must be regarded as exceptionally high. A safer calculation will be based upon the yield of 100 bushels of sweet potatoes per acre, a little above the average of the yield of the potato, or a total of 5,500 pounds per acre. One quarter of this amount is fermentable matter—about 1,400 pounds—which would yield, approximately, 700 pounds of 95 per cent alcohol, or 100 gallons of 95 per cent alcohol per acre. In addition to the sugar in the form of sucrose, or common sugar, which the sweet potato contains, there is also an appreciable amount of non-crystallizable sugars. The total sugars in the sweet potato have not been overstated in the above estimate. In fact, the contrary, rather, is true, since the two sugars together probably average about 6 per cent of the weight of the potato. If the average quantity of starch in the sweet potato is 20 per cent, which is rather a low estimate, the total fermentable matter in the sweet potato is 26 per cent instead of 25 per cent, as estimated above.

Effect of Storage on Composition.—Experiments have shown that the quantity of starch diminishes and the quantity of sugar increases on storing. Further, it may be stated that in the varieties of sweet potatoes which are most esteemed for table use there is less starch and perhaps more sugar than are stated in the above examples. In one instance of an analysis made on the 7th of January of stored potatoes, the starch had fallen to a little less than 13 per cent, while the sugars had increased to over 11 per cent. The total quantity of fermentable matter, however, as will be seen, had not been greatly changed, although there was probably a slight loss.

Utilization of Waste Material or By-Products.—Stalks of Indian Corn and Sorghum.—The stalks of sweet corn, field corn, and sorghum contain large quantities of sugars, and also considerable amounts of starch at the time of the hardening of the starch in the seeds. When sweet corn is harvested for the market its stalk contains considerable quantities of fermentable matter, as has already been stated. Large quantities of this material are grown in the United States every year, and after the harvest of the sweet corn for the market the stalks are utilized chiefly for fodder. In the curing of the stalks for fodder the sugars ferment and disappear. If these stalks could be used economically they would add largely to the raw materials from which alcohol could be made. The technical difficulties, however, attending the utilization of the stalks are so great that it is doubtful whether means can be devised whereby their use may be made profitable for alcohol making. Notwithstanding this, it is a matter which is well worthy of investigation, because if stalks of sweet corn and field corn could be utilized they would place at the disposal of the manufacturer an almost inexhaustible source of raw material from which alcohol might be made. At the present time, however, there is no immediate probability of the economic utilization of this material.

The stalks of sorghum, as is well known, contain very large quantities of fermentable matter at the time of ripening. All of these bodies—that is, the stalks of sweet corn, field corn, and sorghum—contain, in addition to the sugar, notable quantities of starch and gum, which after conversion into a sugar, by malt or otherwise, add greatly to their value for alcohol making. In so far as the question of raw materials is concerned there are no other sources available in the United States so abundant as those found in sweet corn, field corn, and sorghum stalks.

The great difficulty encountered in connection with the utilization of these materials is that the season in which these stalks are suitable for utilization in the manufacture of alcohol is very limited. For instance, in the vicinity of Washington none of these stalks would be available until the latter part of July, and their availability would not continue later than the middle or the end of October under the most favorable circumstances. This gives at most a manufacturing period of only two or three months. The cost of preserving the stalks for a longer period would probably be so great under present conditions as to preclude the possibility of the remunerative manufacture of alcohol therefrom. In consideration, however, of the tremendous extent of this source of supply, it seems advisable that those in charge of the agricultural experiment stations and other experimental investigators throughout the country should study the possibilities of manufacturing industrial alcohol at remunerative rates, at least during a part of the year, from these waste products of the maize crop.

Molasses.—The utilization of the waste materials from the sugar factories and sugar refineries for the purpose of making alcohol is a well-established industry. The use of these sources of supply depends, of course, upon the cost of the molasses. When the sugar has been exhausted as fully as possible from the molasses the latter consists of a saccharin product, containing considerable quantities of unfermentable carbohydrate matter, large quantities of mineral salts, and water. In molasses of this kind there is probably not more than 50 pounds of fermentable matter to 100 pounds of the product. Assuming that a gallon of such molasses weighs 11 pounds, it is seen that it contains 5½ pounds of fermentable matter, yielding 2¼

* Abstract of Farmers' Bulletin 268, issued by the Department of Agriculture.

pounds of industrial alcohol of 95 per cent strength. It requires about 3 gallons of such molasses to make 1 gallon of industrial alcohol. The quantity of molasses made in the United States as a residual product from the sugar manufacture is difficult to determine. For each ton (2,240 pounds) of sugar produced we may assume that there are 62½ gallons of molasses. Placing the total output of sugar in the United States at 400,000 tons, beet and cane combined, would give a yield of molasses of 25,000,000 gallons.

The quantity of molasses produced in Cuba is three or four times as great as that produced in the United States, thus affording a very extensive source of production of industrial alcohol should it prove profitable to make it from this material. The above data show that when the price of molasses delivered to the refineries falls as low as 5 or 6 cents a gallon it may be considered a profitable source of alcohol.

In 1905, 13,500,000 gallons of alcohol were produced in France from beet-root molasses. The production from this source is decreasing—in 1901 almost double the above amount was made.

Wood Pulp and Sawdust.—Many attempts have been made to produce alcohol for industrial purposes from sawdust, wood pulp, or waste wood material. The principle of the process rests upon the fact that the woody substance is composed of cellulose and kindred matters which, under the action of dilute acid (preferably sulphuric or sulphurous) and heat, with or without pressure, undergo hydrolysis and are changed into sugars. A large part of the sugar which is formed is non-fermentable, consisting of a substance known as xylose. Another part of the sugar produced is dextrose, made from the true cellulose which the wood contains.

The yield of alcohol in many of the experiments which have been made has not been very satisfactory. It is claimed, however, by some authors that paying quantities of alcohol are secured. In Simmonsen's process for the manufacture of alcohol one-half per cent sulphuric acid is employed and from four to five parts of the liquid heated with one part of the finely comminuted wood for a quarter of an hour under a pressure of nine atmospheres. It is claimed by Simmonsen that he obtained a yield of 6 quarts of alcohol from 110 pounds of air-dried shavings. Another process which has been tried in this and other countries for converting comminuted wood into alcohol is known as Classen's. The comminuted wood is heated for fifteen minutes in a closed apparatus at a temperature of from 248 deg. to 293 deg. F. in the presence of sulphurous acid (fumes of burning sulphur) instead of sulphuric acid. It is claimed by the inventor that he has made as much as 12 quarts of alcohol from 110 pounds of the air-dried shavings. There is reason to doubt the possibility of securing such high yields in actual practice as are claimed in the above processes. That alcohol can be made from sawdust and wood shavings is undoubtedly true, but whether or not it can be made profitably must be determined by actual manufacturing operations.

Waste Products of Canneries, etc.—There are a great many waste products in the fruit industry, as well as in the canning industry, which contain sugar and starch, and it has been proposed to use these for the manufacture of alcohol. It is true that all waste products which contain sugar or starch may be used for alcohol-making purposes, but it is doubtful if many of them will be found of a character which will permit their use in competition with other materials containing larger quantities of fermentable matter. The principal waste materials which may be considered in this connection are the refuse of wine making, fruit evaporating, and canning industries, especially the waste of factories devoted to the canning of tomatoes and Indian corn. In addition to this, the waste fruit products themselves, which are not utilized at all, as, for instance, the imperfect and rotten apples, tomatoes, grapes, etc., may be favorably considered. The quantity of waste products varies greatly in different materials.

The quantities of waste material in grapes and apples, as shown by Lazenby, are as follows: About 25 per cent of the total weight in grapes, with the exception of the wild grape, where it is about 60 per cent; with apples the average percentage of waste was found to be 23.8 per cent from twenty-five varieties. This included the waste in the core, skin, and the defective apples caused by insects, fungi, bruises, etc. In general it may be said that in the preparation of fruits for preserving purposes about 25 per cent of their weight is waste, and this, it is evident, could be utilized for the manufacture of alcohol. If apples be taken as a type of fruits, we may assume that the waste portions contain 10 per cent of fermentable matters, which, however, is perhaps rather a high estimate. Fifty per cent of this might be recovered as industrial alcohol. Thus, each 100 pounds of fruit waste in the most favorable circumstances might be expected to produce 5 pounds of industrial alcohol. The quantity of waste which could be utilized for this purpose would hardly render it profitable to engage in the manufacture. A smaller percentage could be expected from the waste of the tomato, where the quantity of sugar is not so great. In the waste of the sweet-corn factory the amount of fermentable matter would depend largely on the care with which the grain was removed. There is usually a considerable quantity of starchy material left on the cobs, and this, with the natural sugars which the grown cobs contain, might yield quite large quantities of fermentable matter. It would not be profitable to erect distilleries simply for the utilization of waste of this kind, but if these wastes could be utilized in distilleries already established it might be profitable to devote them to this purpose.

SAFEGUARDS AGAINST FIRE.*

Good fire protection necessitates first, that the least amount of combustible material should be used in constructing a building; second, that the construction should be such that it would tend to limit a fire to the place of origin; third, that the furnishings should be so arranged that the possibilities for fire are reduced to a minimum; and, fourth, that means for the ready extinguishment of a fire should be provided at well chosen places. Underwriters' boards and associations substantially recognize the importance of these precautions, but property owners do not always give them the consideration which they deserve.

For economical and other reasons, the work of the fire protection engineer should be done conjointly with that of the architect and the structural engineer. Proper consideration for the possibility of fire at the time of preparing building plans not only means a large saving in the cost of installing private fire protection apparatus, but also permits of its arrangement so as to be most effective.

A bucket of water or of chemical solution, if intelligently used, is nearly always sufficient to put out a fire if readily available near the incipient blaze. But a bucket of water is not always handy, and frequently there is no one near to use it; consequently, good fire protection must necessarily depend upon distributed automatic devices. The usefulness of the automatic sprinkler is pretty generally recognized by property owners and underwriters. It is worthy of note that the rates of insurance on Class C buildings equipped with these are lower than on Class A buildings, without them.

Sprinklers are not intended to check conflagrations, but to extinguish or control fires in their incipiency. In a properly installed sprinkler system, the presence of fire is made known by the striking of a mechanical alarm which is operated by a water motor set in motion by the opening of one or more fusible heads. The electric alarm is uncertain of operation and should be installed only as auxiliary to the mechanical alarm. A very complete alarm system may be seen at the Pacific Hardware and Steel Company's building in San Francisco. Not only are the mechanical alarms set in operation, but drop annunciators indicate the section of building, the story, and the portion of floor where the head is discharging.

Inside stand pipes with hose constantly attached, and approved chemical extinguishers are of great value in augmenting protection afforded by automatic sprinklers.

Ridge, cornice and window sprinklers are efficient in lessening the danger from exterior fires. While metal-clad wooden frames containing ordinary glass are poor apologies for fireproofing, properly constructed metal frames fitted with wire glass and used in conjunction with window sprinklers connected to proper water supplies are equal if not better than any shutter manufactured. The latter soon deteriorate from weather and lack of attention, and are rarely closed when they should be. Roof tanks of gravity flow, except as secondary supplies to sprinkler systems, are practically useless for fire purposes when the discharge is less than fifty feet below the tank bottoms.

Basement reservoirs with flexible and non-deteriorating linings and flowing wells, both of sufficient capacity and furnishing suction for steam or gasoline-driven pumps, are the solution of perfect private water supplies in sections susceptible to seismic disturbances. This point is borne out by the operation of pumping plants at the Palace Hotel, Merchants' Exchange, Western Electric Company, and Center's Wells after the earthquake of April 18. The building of the Western Electric Company was saved from destruction more through the private water supply than by its wire-glass windows. Electrically-driven pumps are impracticable on account of uncertainty in the supply of current.

Fire is a chance occurrence which breaks out without any warning; hence, fire-fighting apparatus should be as self-sustaining as possible, as well as fool-proof.

Apprenticeship schools in operation during working hours under the charge of a trained teacher are effective means of developing the mentality of the organization and at the same time of getting in close touch with the employee early in his career, and the longer he stays with the concern and the more money is spent on his improvement the more valuable he becomes as an asset and the greater the effort should be made to retain him in the organization. Schools should be established in the factory during evenings for the purpose of helping the employee to advance in the organization. Energy, coupled with character and knowledge, guided by tact and discretion, will open the avenues of achievement. Care should be taken, however, not to coddle the organization. Coddling engenders weaklings. Extending opportunities so that the employees can help themselves develops self-reliance, self-respect, and, at the same time, regard for the management. Such a policy promotes a strong and healthy organization. Employees are quick to feel any interest taken in their welfare and as quick to reciprocate. To increase the efficiency of an organization so that each employee is not only a passenger in the enterprise but effectively pulls his own weight is the function of Industrial Engineering. To do this with a spirit of honesty and fair dealing between employer and employee is a delicate mission. It embraces a wide field of activity in the world of advance in which industry is the leading exponent. Apart from the practical results obtainable by the foregoing methods of management, lies the fact that it is by instituting only the highest methods that employers are utilizing their privilege as men and citizens to help in the march of mankind toward progress and enlightenment.

* Abstracted from an address delivered before the Structural Association on September 6, 1906, by Mr. George J. Wellington, fire protective engineer.

SCIENCE NOTES.

During the past four hundred years there has been a most significant, although gradual, development in the university organization. This has been a necessary result of the evolution of knowledge. The earliest continental universities found a reason for their being in the dissemination of a system of scholastic learning which had little to do with the affairs of men. A body of learning based chiefly, if not wholly, upon certain conventional systems of abstract knowledge, like the Aristotelian logic, transmitted with little or no change from the masters of antiquity, constituted essentially all they had to offer to their students. The instruction consisted almost entirely of certain exercises in this intellectual inheritance practically unchanged through the centuries of its transmission. This mental training had essentially no relation to or bearing upon the actual things of human experience, nor had it much effect upon national life or upon any of the varied interests of the community.

In the Astrophysical Journal, Mr. H. M. Reese describes an experiment in illustration of the performance of diffraction gratings. "The scheme was to produce, on the surface of mercury, ripples emanating from a series of equidistant points distributed along a straight line." To produce these a thin sheet of iron was cut into the form of a comb of sixteen teeth, spaced 5 millimeters apart, and attached to the lower prong of an electrically-driven tuning fork arranged to vibrate in a vertical plane. This comb was set near the edge of a tray of mercury in such a way that the teeth would dip into the surface. When the ripples were examined stroboscopically it was seen that near the comb they mixed together chaotically; but at a moderate distance they resolved themselves into several series of regular rectilinear wave-trains, which advance in different directions and are symmetrically distributed. These correspond to the spectrum of zero order—moving out in a direction normal to the comb—and spectra of orders one and two on each side. An image of the ripples can be projected on a screen. To do this most successfully it must be arranged so that the projecting lens receives as much light as possible from the source. This is brought about if a converging beam from a lantern is incident upon the mercury and the projecting lens is placed at the point of convergence of this beam after reflection.

An interesting and well authenticated account is given by Landreth, in Proc. Amer. Phil. Soc., of an instance of persistent vitality in seeds. Lieutenant Greely, commander of the Lady Franklin Bay expedition, which sailed north in 1881, took out seeds of various vegetables noted for their antiscorbutic properties. Some of these were sown at Fort Conger, 81 deg. 44 min. north, but the attempt was not successful. This station was abandoned in 1883. In 1899, sixteen years later, the abandoned station at Fort Conger was discovered by Lieut. Peary, commander of the North Polar expedition. Among other things found was a packet of radish seed in an open box in the attic of the fort. These seeds had been exposed during sixteen years to a winter temperature of 60 deg. to 70 deg. F. below zero. The seeds were sent home and remained until the spring of 1905, when they were sown and 50 per cent produced perfectly normal plants. The original seed was harvested certainly not earlier than 1880, and consequently was twenty-three years old when sown. The question is raised as to whether the electrically charged atmosphere, so constant in northern regions, has the effect of prolonging germinative force. It has been observed that the atmospheric electric currents add quite 100 per cent to the rapidity of plant growth, and to the development of color and strength of perfume.

Not less important than the service which science can render to existing industries and their extension is that which it can contribute to the problem of ascertaining and rendering available for the manufacturer vast undeveloped resources. Our own experience and the example of other countries have shown that such work cannot be systematically carried on by private enterprise. Upon its successful accomplishment depends, not only the unrestricted supply of the necessary raw materials for which the manufacturer looks in increasing quantity, but also the prosperity of the country which produces these materials. This success can only be brought about by a combined effort on the part of the manufacturer and of the government. The manufacturer can provide information as to the materials he needs. The preliminary work of discovering suitable material by scientific means, as several foreign governments have already recognized, must be endowed, directed, and carried on with imperial funds. It cannot be expected that private enterprise will take steps to explore the resources of little-known countries on the chance of a particular material being discovered, nor can the work, as a rule, be successfully done by this means. Experience shows that the most effective manner of promoting the commercial development of a new country is for the government to carry out systematically with its own officers the preliminary work of exploration and examination of the natural

resources, with the aid of such technical advice as may be necessary from manufacturers and users, and then, having established the fact that particular products of value can be found or cultivated in a given country, to leave commercial enterprise to do the rest. By action on these lines immense progress is being made in French, German, and Dutch possessions, while the United States government has taken similar action with the Philippines.

ENGINEERING NOTES.

Feed-water heaters arranged to circulate steam through the coils, the water being between the pipes and the shell, deteriorate, as a rule, more rapidly than when the water circulates through the coils surrounded by steam. Cast-iron shells are preferred by many engineers to those made of steel plate on account of their greater durability. Steam-tube heaters provide much greater storage capacity for hot water than do those of the water-tube type, as might be expected. Storage capacity means that more time is afforded for the settlement of impurities, any heavy sediment being removed through the mud-blow, lighter impurities being discharged through the surface blow-off.

Perhaps one of the greatest things in favor of suction gas producers is the fact that they will work well with coal of inferior quality, containing as much as 6 per cent of volatile matter and 9 per cent of ash. It is usually recommended that anthracite coal should be used for gas generators, although it should be certain selected coal for the purpose, and the advice of the maker of the plant should certainly be sought upon this subject. Trouble rather than economy is usually obtained if an attempt is made to use a cheaper coal than is recommended. All of the so-called failures might almost be traced to those in charge of suction gas producers failing to carry out the instructions and recommendations of the maker. It is essential for suction gas generators that there should be no undue resistance to the suction of the air and of the gas which is generated. Therefore the coal should be of such a size that this comparatively free passage may take place. Roughly speaking, we may say that the size most suited for suction gas generators from all points of view is that which is about the size of a hazel nut. Incidentally, it may be well to recommend that only the driest coals should be used, and those which have little or no tendency to coke or clog together. Similarly, coal which becomes pulverized with the heat of the fire is not suitable. If the coal contains too much ash it is liable to choke up generators, and the coal should contain as little tar as possible, because this collects in the bends and pipes and clogs up the valves of the gas engine. It may be mentioned also that tar tends to cause premature ignition in gas engines, which is a most serious thing in those of large size.

Demand creates supply, therefore there would not have been the increased steel production in America if it had not been for the development and growth of the country; and it is collaterally true that without the discovery and expansion of the making of Bessemer and other mild steels, that growth would have been impossible. While the present American railways with their equipment would be absolutely impossible with iron rails, it is also true that their development has necessitated a change in the characteristics of the steel rails used. In the early seventies, when steel rails began to replace iron ones, the section required was not over 60 pounds and more generally 56 pounds to 58 pounds to the yard, and the increased service obtained from them was regarded as wonderful. But, nevertheless, the wisdom of their use was not at once unanimously accepted. One of the leading English technical journals for a long time warmly championed the continued use of iron rails. Naturally, the term steel carried with it an idea of hardness, and consequent brittleness, hence the fear of an all-steel rail. Much time and money were spent in unsuccessful experiments with iron rails having steel heads. These conditions led to making the steel rails of as soft a composition as could then be successfully accomplished. Had ferro-manganese been then known, the early rails would have been rolled from dead soft metal. Let this be as it may, it is true that, while the early steel rails were of very irregular chemical composition, the aim was to keep the carbon content not to exceed 0.30 per cent, and somewhat later, not over 0.40 per cent. Undoubtedly, owing largely to the care exercised in the physical treatment of the metal during the manufacture of the rails, most excellent results were obtained, and gradually familiarity with them dispelled the fear of breakage. And it was not long before railway officials realized that their use permitted increased loads and speed. Traffic demands and better financial conditions led to increasing the weight of the rail sections, and also the hardness of the metal in them, but the same causes also led to heavier wheel loads of both engines and cars, and faster schedules.

Huxley says: "There are two opposing methods at work in the government of the world, respectively, the ethical and the cosmic. The practice of that which is ethically best involves a course of conduct which in all respects is opposed to that which leads to success in the cosmic struggle for existence. In place of thrusting aside or treading down all opposition it requires that the individual shall not merely respect but help his fellows. Its influence is therefore directed not so much to the survival of the fittest, but the fitting of as many as possible to survive."

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